EFFECT OF SUPPLEMENTATION OF BYPASS FAT DURING PRE AND POST PARTURIENT PERIOD ON LACTATION PERFORMANCE OF CROSSBRED COWS

THESIS

Submitted

in partial fulfillment of the requirements for the Degree of

MASTER OF VETERINARY SCIENCE

IN

ANIMAL NUTRITION

BY

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(INDIA)

2015

DECLARATION OF STUDENT

I hereby declare that the experimental research work and interpretation of the thesis entitled **"EFFECT OF SUPPLEMENTATION OF BYPASS FAT DURING PRE AND POST PARTURIENT PERIOD ON LACTATION PERFORMANCE OF CROSSBRED COWS"** or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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We also certify that the thesis or part of there has not been previously submitted by him for degree of any other university.

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF SUPPLEMENTATION OF BYPASS FAT DURING PRE AND POST PARTURIENT PERIOD ON LACTATION PERFORMANCE OF CROSSBRED COWS"** submitted by **Shri. RUMNE ABHINEET ASHOK** to the Maharashtra Animal and Fishery Sciences University in partial fulfillment of the requirement for the degree of **Master of Veterinary Science (M.V.Sc.)** has been approved by the Student's Advisory Committee after examination in collaboration with the External Examiner.

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Acknowledgement

I would like to thanks my father and mother whose love and blessings were always there for me during my entire thesis period.

"The Culmination of research work is a corner stone in the life of any student with the research guide the driving force behind".

The above quote holds true to express my deep sense of gratitude to my honorable teacher and research guide **Dr. B. N. Ramteke Sir**, Associate Professor, Department of Animal Nutrition, Bombay Veterinary College, Bombay who motivates me to expand my horizons to encompass the vast keen of knowledge and channelize my efforts in an altruistic manner, without whom this study would not have been possible. It was great honor for me to work under his guidance. I shall forever remain an admirer of his interest in work, his deep knowledge and his approach to the subject, his love for his students and his constant co-operation throughout my entire research work and post-graduation studies.

I would like to give sincere thanks to one of the most polite and humble human **Dr. Dhonde Sir** member of Pashuvishwa Agrovet Rahuri, Dist- Ahemadnagar who was the soul of my thesis work, his greatness helped me throughout my thesis work. His reference helped me to conduct my thesis on Manoj Dairy Farm. His financial and moral support helped me a lot. He taught me a lot about agriculture, veterinary science, communication skills and most important a sense of loyalty to farmers. He provided me all the necessary help during my thesis work. In short he was the backbone of my thesis work.

I would also like to thanks **Dr. P.L. Dhande Sir, Dr. S.S. Chopade Sir, Dr. G.M. Gadegaonkar Sir and Dr. S.D. Ingole Sir** for guiding me for my thesis work. I would also like to express my sincere thanks to **Dr. N. R. Karambele Sir** and **Dr. S. D. Jagdale Sir.**

I would like to give special thanks to **Dr. U. B Kumbhar Sir** because of whom I got a kick start for my thesis work.

I would like to thanks all other members of Pashuvishwa agrovet including **Dr.Nimse Sir, Dr. Sayyad Sir, Dr. Yewale Sir, Mr. Amol and Mr. Somnath** for their selfless support.

It were the farmers, **Sambaji Dhokane, Sonyabapu Dhokane, Ashok Dushing, Shivaji Dhokane and Deepak Dhokane** who were the main pillars of my thesis work. Though academically uneducated their practical knowledge regarding fodder production and animal rearing was worth learning. Their qualities like understanding the environment, hard work, gentleness, politeness and most important a co-operative nature was worth learning.

I would like to thanks **Mahatma Phule Krishi Vidyapeeth, Rahuri** who have constructed a farmers residence where outsider students/farmers can stay at an affordable rate and carry out educational training programmes.

I am very thankful to Ashish Life SciencePvt Limited, Andheri (East), Mumbai, for provision of bypass fat and financial support during my M.V.Sc. Research work. I am indebted to Dr. Nitesh Kadam , Business Development Manager, Ashish Life Science Pvt Limited, Andheri (East), Mumbai.

I would like to thank my juniors **Sachin Raut, Irfan Sayyed, Sachin Khemlapure, Ranjit Sejule, Ashok and Alee** for helping me during my thesis work. My friends **Vishal Suryawanshi, Aviraj Satpute, Chintamani Chavhan, Ashok Bhalerao** and **Alee** helped me a lot for my thesis. I would like to thanks my seniors **Anil Bhosale , Sujay Mali, Girish Gawali and Sachin Khemlapure.**

I would like to thanks my brother **Dr. Abhijit Rumne** and my sister **Anjali Arya** for their immense help.

I would like to conclude my acknowledge part by giving thanks to two girls who motivated me for doing post graduation far away from my home town and never complained me for delay of my work. It was very difficult to stay away from them and concentrate on my work. But their love and support helped me a lot. So lots and lots of thanks to my wife **ROHINI ABHINEET RUMNE** and my cute and naughty daughter **MOKSHA**.

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LIST OF ABBREVATIONS

DM	Dry matter	ADF	Acid Detergent Fibre
OM	Organic matter	NDF	Neutral Detergent Fibre
CP	Crude protein	DMI	Dry matter intake
EE	Ether extract	TDN	Total digestible nutrients
CF	Crude fiber	DCP	Digestible crude protein
NFE	Nitrogen free extract	FCM	Fat corrected milk yield
TA	Total ash	TS	Total solids
Ca	Calcium	SNF	Solid not fat
P	Phosphorous	VFA	Volatile fatty acid
mg	Milligram	Kg	Kilo grams
gm	Grams	Ppm	Parts per million
@	At the rate	BCS	Body condition score
d	Day	H	Head
w	Weight	V	volume
P	Level of significance	DMB	Dry matter basis
ME	Metabolizable energy	AIA	Acid insoluble ash.
Ca-LFA	Calcium soaps of long chain fatty acids	FA	Fatty acids

1. INTRODUCTION

Agriculture, with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. Animal husbandry has a pivotal role in agriculture sector contributing 24.8% to agriculture gross domestic product. Dairy industry is one of the important aspects of animal husbandry.

India is leading country in milk production, producing 137.7 million tonnes of milk with an annual growth rate of 3.97% (DAHD, 2014). However, compared with other major world dairy producers the average milk yield is poor, reflecting that technological input is low. While in India the average milk yield per dairy cow per year is estimated to be 1,284 kg, the figure is very low as compared to 6,212 kg in the European Union and 9,117 kg in the United States (worldanimalprotection.org). Poverty, unavailability of good quality fodder, environmental crisis, and poor managemental practice are some of the potential problems face by marginal farmers.

Most of the animals in developing countries including India are fed on agricultural by-products and low quality crop residues, which have got inherent low nutritive value and digestibility. The shortage of feed resources coupled with their poor nutritive value is of major concern to low productivity of dairy animals. High producing dairy animals in early lactation do not consume sufficient dry matter to support maximal production of milk (Goff and Horst, 1997). Demand for energy is very high during early stage of lactation but supply is not commensurate with demand in particular physiological stage or limited intake may affect production potential of animal in the whole lactation length (Sirohi *et al.* 2010). Hence, during early lactation, dairy animals are often forced to draw on body reserves to satisfy energy requirements (negative energy balance); this leads to substantial loss in body weight which adversely affects production, resulting in lower yield (Kim *et al.* 1993).

Cereal grains and fats plays an important role as source of energy in the ration of high yielding dairy animals for optimum productivity but due to use of cereals for human consumption and monogastric animals the alternate source of energy in dairy ration is supplemental fat. Inclusion of unprotected fat in dairy ration is limited to 3% of dry matter (DM) intake, beyond which digestibility of DM and fibre are reduced (NRC, 2001). It has also depressing effect on rumen cellulolytic microbial activity (Ranjan *et al.* 2013). However, by protecting the fats from ruminal degradation, it is possible to increase fat content of the ration up to 6-7% of the DM intake, so that the fats get digested and absorbed optimally in the lower tract for milk and fat production without affecting digestibility of dry matter and fibre. It is stated that supplementing ration of lactating animals with bypass fat enhances energy intake in early lactation which reduces deleterious effect of acute negative energy balance on lactation (Tyagi *et al.* 2010).

The term “protected fat” is most applicable to fat sources specifically designed to resist bio-hydrogenation by ruminal microbes and modify fatty acid profile of body tissues and milk. Many of the protected fats are based on surrounding unsaturated fatty acids by a protective capsule, such as formaldehyde-treated proteins, that act to shield the internal fatty acids from bio-hydrogenation.

The term “rumen-inert” has been assigned to fats that were specifically designed to have little, if any, negative effect on feed digestibility when fed to dairy animals. Rumen-inert fats are often high in calcium salts of fatty acids, saturated fatty acids, or hydrogenated fats. Fats in this category have also been referred to as “bypass” fats. Fats produced from animal and vegetable by-products have been commercially available for a number of years and are less expensive than protected fats. Such fats, however, tend to give variable results due to suppression of rumen microbes which in turn leads to reduce fibre digestibility and often cause fat depression. Protected fats are more expensive but do give more consistent results in high producing cows (Yadav *et al*. 2015).

Supplementation of bypass fat not only increases energy intake but also increase unsaturated fatty acid content of buffalo milk and more economic returns to dairy farmers (Parnerkar *et al.* 2010). Diets containing supplemental fat often stimulate increased milk production because of increased energy intake, improved efficiency of utilization of energy, or both. Bypass fat in the form of calcium salts of fatty acids (Palm oil and others) has been known to increase energy density of the ration without adversely affecting the dry matter intake and digestibility (Naik *et al*. 2009). It also help to increase milk yield and milk fat percentage or both (Chouinard *et al*. 1998). Several workers studied responses to supplementation of bypass fat and reported to increase milk and FCM yield in lactating buffaloes (Shelke *et al.* 2012) and milk fat percentage in dairy cows (Sirohi *et al.* 2010). The positive effect of feeding Ca salt of fatty acids was more evident at the early lactation in buffaloes (Garg *et al,* 2002)

Beside this, the transition period in the dairy cow is the most critical phase of the lactation cycle. The transition period is typically considered 3 weeks before calving to 3 weeks after calving. Three weeks prepartum until three weeks postpartum is marked by declining dry matter intake (DMI) as the cow approaches parturition and negative energy status in early lactation. Depression of feed intake pre-calving and slow intake increase post-calving is observed during this period. The energy requirements of dairy cows increase by 23% to support foetal and gravid uterus growth in the last month of pregnancy (Moe and Tyrrell. 1972). The DMI starts to decline approximately 3 weeks before parturition and reduce dramatically in last 7 days. The level of decline has been as high as 30% (Bertics *et al.* 1992). Total energy intake in early lactation is usually less than what is required for maintenance and milk production (Staples *et al*. 1990) therefore the cow must mobilize adipose stores in the form of non-esterified fatty acids (NEFA) to support lactation. Non-esterified fatty acids are removed from circulation by the liver. Once in the liver, NEFA are utilized for energy; however ruminants have reduced ability to export triglycerides from the liver and lipids can accumulate causing a metabolic disorder known as fatty liver (Drackley, 1999). Supplemental unprotected fats can increase the energy density of the diet and reduce an energy deficit in early lactation. However milk production often increases when fats are added to the diet, resulting in no improvement of energy status. In addition, fat feeding can often result in a depression of dry matter intake (Allen, 2000). The mechanisms by which supplemental fat depresses DMI are not apparent but could involve negative effects on ruminal fermentation and gut motility, release of gut hormones, oxidation of fat in the liver, and palatability of diets containing added fat. Feeding supplemental fat in the form of Ca salts of fatty acids (CSFA) makes the fat partially inert in the rumen and sometimes can prevent a depression in DMI. Feeding CSFA can allow specific fatty acids (FA) to escape ruminal biohydrogenation which are then available in the small intestine for absorption and utilization. The modern dairy cows and buffaloes may be deficient in the essential FA, Linoleic acid (LA) (Sanchez and Block, 2002). Providing LA in the form of CSFA may reduce a deficiency and act on target tissues in addition to increasing the energy density of the diet. Decreased incidence of disease in early lactation can result in increased milk production throughout the lactation and an increase in reproductive efficiency.

In India, several trials have been conducted on crossbred cattle and buffaloes on feeding of bypass fat, to see its effect on milk production. Also the bypass fat technology holds promise in terms of economic viability.

However very scanty work was conducted on effect of bypass fat supplementation simultaneously during prepartum and postpartum in dairy animals. Hence the present trial was undertaken with the following objectives.

1. To study the effect of bypass fat supplementation on milk yield and its composition in postpartum cows
2. To study the effect of bypass fat supplementation on feed intake and efficiency of feed utilization in cows
3. To study body condition score of experimental animal
4. To study the economics of feeding bypass fat in lactation

2. REVIEW OF LITERATURE

High yielding dairy cows during prepartum and early lactation are always in negative energy balance because of insufficient availability and/or reduced feed intake to meet energy requirements. Due to this, animals have to draw upon their body reserves of fat to support the milk production and other vital functions, often resulting in metabolic disorders such as fatty liver and reduced milk yield (Kronfeld, 1982). This also leads to reduced productive and reproductive performances in tropical countries like India. Maximizing energy intake by increasing the energy density of the diet is a logical feeding strategy for early lactating animals. Excessive grain feeding increases energy density of the diet, but rapid ruminal fermentation leads to acidosis (Radostits *et al*. 2000) and decline in milk fat percent. Fat supplementation also increases energy density of the diet, but high dietary fat can hamper digestion in the rumen and a decline in milk fat percentage, depending on the amount and type of the fat fed. To prevent these undesirable effects, supplementation of bypass fat as calcium salts of long chain fatty acids are a good alternative as it is inert in rumen. Saturated and unsaturated long chain fatty acids have less effect on rumen fermentation when supplemented as calcium salts than as free fatty acids (Chalupa *et al.*1985)

In this section, the influence of feeding bypass fat on feed intake, milk yield and its composition, efficiency of feed utilization and economics of feeding has been reviewed.

2.1. Bypass fat feeding:

2.1.1. The concept of bypass fat technology:

In developing countries, the energy density of rations fed to high yielding dairy cow is lower than what is actually required, as use of concentrates is limited. Feeding of rations having lower energy content, can adversely affect the productive and reproductive performance of dairy animals.

2.1.2. Methods of protection of fats

Devasena *et al.* (2007) summarized several methods to formulate fat which is inert in the rumen environment so as to supplement fat at sufficient levels to achieve maximum production without any adverse effect on fiber digestion and rumen fermentation.

1. **Natural protection**: Cottonseeds contain protected protein and protected fat in natural form and feeding of cotton seed cake can increase the supply of protein and energy to animal.

2. **Crystalline fat**: Crystalline fat is generally made up of saturated fatty acids. These do not melt at rumen temperature and thus, are resistant to ruminal hydrolysis.

3. **Poly unsaturated fatty acids (PUFA)**: PUFA fed in small quantity may get hydrogenated and try to remove hydrogen ions from the rumen, so that the extra fat given is not subjected to bio-hydrogenation.

4. **Fatty acyl amides**: Fatty acyl amides are prepared by mixed anhydride method and are known to be resistant to ruminal bio-hydrogenation.

5. **Encapsulation with formaldehyde treated protein**: Protein-fat complex in crushed oilseeds can be treated by formaldehyde (Ashes *et al.,* 1979). However, this method did not receive commercial application due to the problems associated with formaldehyde use.

6. **Calcium salts of long chain fatty acids**: Calcium salts of long chain fatty acids are not soluble in rumen and therefore do not disturb organic matter digestibility and the effect is due to ionized calcium (Elmeddah *et al*. 1991; Alexander *et al*. 2002). This method is widely used to protect fat in rumen.

7. **Prilled fatty acids**: Saturated fatty acids are liquefied and spraying the mixture of fatty acids under pressure into a cooled atmosphere, results in dried prilled fatty acids, which are inert in the rumen (Grummer, 1988).

8. **Extrusion of oil seeds**: Extrusion cooking is another method to prevent bio-hydrogenation of fatty acids in the rumen (Devasena *et al.,* 2007).

Out of all these methods, the calcium salts of long chain fatty acids is the most commonly used method, as this method is cheaper and appears to be more effective. The production of calcium salts of fatty acids can be done by two methods *viz*. (1) Fusion Method and (2) Double Decomposition Method.

Fusion Method:

In this method, oils and fatty acids are heated with calcium oxide or calcium hydroxide in the presence of catalyst, in a closed vessel at a required temperature and pressure. Water produced during reaction and the added water is driven off as stream and the resulting product is hard mass of saponified salts of fatty acids or bypass fat. It is single step method, so very simple and user friendly (Naik *et al.* 2007).

Double Decomposition Method:

This method requires heating of the known quantity of fat in a metal container, followed by addition of an alkali (aqueous sodium hydroxide solution) in the melted fatty matter with constant stirring till the fatty acids gets dissolved completely. After saponification, the heating is stopped. While the contents are still warm, calcium chloride solution is added slowly to the water soluble sodium soap with constant stirring, which ultimately causes precipitation of calcium soaps. Excess water is then removed by filtration. The calcium soap is then dried at low temperature and the lumps are broken and grounded before used as protected or bypass fat. Bypass fat dried at room temperature are easily transportable and can be mixed into diets without creating specialized infrastructure.

Earlier, bypass fat was imported in India. Some industries have collaboration with foreign firms to manufacture bypass fat, but at limited extent. The trials of feeding of this indigenously prepared bypass fat to dairy animals were conducted by NDRI, NDDB and G.B. Pant University of Agriculture and Technology, Pantnagar and reported significant increase in the milk yield. Efforts are also directed to use cheaper oil resources for manufacture of bypass fat. Different by-products from edible/non-edible oil industries and other unconventional oil supplements have been tried, for the preparation of bypass fat, with objective to make these technologies commercially viable and cost effective. The rumen protected fats such as oil seeds, casein-formaldehyde protected fat, crystalline fat, fatty acyl amide hydrogenated tallow or triglycerides and calcium salts of long chain fatty acids (Ca-LCFA) are being used. Ca-LCFA is relatively less degradable in the rumen (Elmeddah *et al.* 1991), has the highest intestinal digestibility and serves as an additional source of calcium.

2.1.3. Potential sources of protected fat:

Different vegetable oils have been screened by different researchers for their stability in the rumen. Tangendja *et al.* (1993) reported that rice bran oil was suitable to be used as rumen protected fat based on *in vitro* studies. Whereas, Reddy *et al.* (1999) found the potential of red palm oil as the vegetable fat source for calcium soap formation. Kowalski (1997) used *karanj, kusum, mahaua oil* and palm fatty acid distillate (PFAD) as a source of bypass fat for *in vitro* studies. Gulati *et al.* (1997) showed that calcium soaps of long chain fatty acids are relatively more inert in the rumen as compared to prilled or extruded fats. Sunflower (Alexander *et al.,* 2002), rapeseed (Garg and Mehta, 1998) and *mahua oil* (Kowalski, 1997) were also used for preparation of calcium soaps of long chain fatty acids for inclusion in the ruminant rations.

2.2. Effect of supplementation of bypass fat:

Kent and Arambel (1988) investigated the effect of feeding Ca-LCFA to dairy cows in early lactation on DMI. Twenty dairy cows were divided in two groups. Group I and II were given total mixed ration with or without added Ca-LCFA, respectively. Each cow in treatment group received 223 g of Ca-LCFA once daily and concluded that the mean daily DMI remained similar between control and cows fed Ca-LCFA. The respective milk and 3.5% FCM production was 35.4, 35.5 kg/d and 34.4, 34.3 kg/d for control and Ca-LCFA, respectively. The mean daily milk and 3.5% FCM production were statistically similar in both the groups**.** The milk fat (3.39 and 3.32%) and SNF (8.56 and 8.58%) for control and Ca-LCFA group, respectively, were similar.

Schneider *et al*. (1988) fed four Holstein cows of 120 days postpartum into two groups. T_1: fed with a basal ration of corn silage, ground corn and Soyabean meal in control group and T_2: fed with basal diet with additional 4% Ca salts of palm oil in treatment group. The fat % and fat yield was significantly ($P<0.01$) higher with supplementation of CSFA (0.5 kg/d). The respective whole milk and 3.5% FCM yield was 20.4, 21.9 and 19.3, 21.6 kg/d which was significantly (P<0.05) higher in CSFA supplemented group.

Schauff and Clark (1989) conducted a trial on lactating Holstein cows fitted with rumen cannulas which were used in two experiments to investigate the effect of supplementing CaLCFA or prilled fatty acids to the diet on milk and FCM production. In experiment I the treatments were: 1) control, 2) control plus 680 g/cow per d of Ca salts of fatty acids (CSFA), 3) control plus 680 g/cow per d of prilled fatty acids and 4) control plus 907 g/cow per d of prilled fatty acids. While in experiment II the treatments were: 1) control, 2) control plus 553 g/cow per d of CSFA, 3) control plus 454 g/cow per d of prilled fatty acids (PF). In experiment I, the respective whole milk and 4% FCM production was 22.8, 24.7, 24.0, and 22.4 kg/d and 19.3, 21.0, 20.0, and 18.3 kg/d. In experiment II, the milk and 4% FCM production was 31.6, 31.6, and 30.4 kg/d and 26.0, 26.1, and 25.0 kg/d for control, CaLCFA and PF group, respectively. The data suggested that milk yield and 4% FCM yield was statistically similar in all treatment groups in both experiments.

Canale *et al.* (1990) carried out a trial on twelve early to mid-lactation Holstein cows (8 multiparous and 4 primiparous) to know the effect of adding Ca salts of fatty acids to the diet that differed in NDF content on DMI. The Ca salts of fatty acid were fed @ 0 kg/cow in T1 group and 0.5 kg/cow in T2 group. The DMI (kg/d or percentage of BW) was (18.1, 18.2, 21.8 and 20.7 kg/d) and (2.9, 3.0, 3.6 and 3.4%) for group 1, 2, 3 and 4, respectively. DMI (kg/d or as the percentage of BW) were not affected by the addition of CSFA. Milk yield and FCM were significantly higher in treatment group than control.

Andrew *et al.* (1991) studied the effect of calcium salts of long chain fatty acids from palm oil in lactating and non-lactating Holstein cows on their milk composition. Animals were fed 1) 16% CP and 0% Ca-LFA, 2)16% CP and 2.95% Ca-LFA, 3) 20% CP and 0% Ca-LFA and 4) 20% CP and 2.95% Ca-LFA, respectively. Milk fat was 3.70, 3.30, 3.56 and 3.57% and SNF was 8.74, 8.45, 8.89 and 8.64% for 1, 2, 3 and 4 groups, respectively. No effect was observed on milk fat content. However, SNF content was reduced in cows fed supplemental fat but they did not differ statistically. Milk yield was higher in treatment group as compared to control.

Sklan *et al.* (1992) investigated the effect of dietary fat as cottonseed, fatty acids, or calcium soaps of fatty acids in high yielding lactating cows receiving low forage on milk and FCM production by using thirty two primiparous and twenty nine multiparous cows per treatment. The treatments were: 1) no added fat (control), 2) 0.43 kg/d of fatty acids, or 3) 0.5 kg/d of CSFA per cow in the concentrate. The respective whole milk yield was 29.0, 30.5, 29.6 kg/d and 31.9, 32.2, 32.0 kg/d, whereas, the 3.5% FCM yield was 24.3, 26.6, 25.9 kg/d and 27.6, 29.0, 28.0 kg/d for primiparous and multiparous cows, respectively. The yield of milk and FCM was enhanced ($P<0.05$) in cows fed both CSFA and free fatty acids. The respective milk fat was 2.67, 2.81 and 2.75%, which was statistically similar. The DMI did not differ among the cows fed control and fat supplemented diets.

Schauff and Clark (1992) carried out an experiment on four ruminally fistulated multiparous Holstein cows averaging 43 days in milk were utilized in 4×4 Latin Square Design with 14-d period. Treatments were: 1) control with 0% Ca-LCFA, 2) 3% Ca-LCFA, 3) 6% Ca-LCFA, and 4) 9% Ca-LCFA. The DMI decreased linearly ($P<0.01$) with increasing amount of Ca-LCFA added to the diet and the values were 25.1, 24.5, 23.7 and 19.6 kg/d for control, 3%, 6% and 9%, respectively. The DMI was extensively reduced significantly ($P<0.01$) when the diet contained 9% Ca-LCFA. Milk production, milk protein and SNF were not altered greatly by inclusion of 3 or 6% Ca salts of long-chain fatty acids in the diet, but inclusion of 9% Ca salts of long-chain fatty acids decreased their production. Calcium salts of long-chain fatty acids increased milk fat percentage and production of fat and FCM when fed as 3 or 6% of the dietary DM but decreased yields of milk fat and FCM when fed as 9%. Calcium salts of fatty acids can be fed to provide up to 6% of the dietary DM without deleterious effects on ruminal fermentation and digestibility of most nutrients.

Kim *et al.* (1993) carried out an experiment to observe the effect of supplemental dietary fat from extruded soybeans and calcium soaps of fatty acids in lactating dairy cows. Thirty-three Holstein cows were assigned to one of the three diets T_1: Control T_2: containing extruded soybean meal (ESB), T_3:

supplemental fat from Ca soaps of fatty acids (CSFA). Dry matter intakes (17.8, 18.4, and 16.6 kg/d) were not significantly different among diets. The respective whole milk and 3.5% FCM production was 29.2, 32.4, 31.8 kg/d and 25.2, 26.7 and 28.7 kg/d which was significantly (P<0.01) higher in ESB and CSFA diet than control group. The milk fat percentages were higher for cows fed Ca soaps of fatty acids (CSFA) (3.20, 2.69, and 3.47%). The percentage of SNF and total solids in the milk were similar for cows fed added fat or different types of fat.

Elliott *et al.* (1996) divided five mid lactating multiparous Holstein cows that were fitted with ruminal cannulas. The treatments were: 1) no added fat (control), 2) 6.1% Ca salt of long-chain fatty acids-CaLCFA, 3) 5.0% prilled long-chain fatty acids, 4) 5.2% prilled hydrogenated palm fatty acids distillate (HPFAD) and 5) 5.2% flaked hydrogenated palm fatty acid distillate. Fat sources were added to supply 5% fatty acids. The respective fat% and fat yield was 3.36, 3.58, 3.77, 3.76 and 3.64 and 0.87, 0.89, 1.00, 0.97, 0.98 kg/d which was statistically similar in all the treatment groups. The DMI was 21.3, 20.0, 21.5, 21.3 and 21.0 kg/d for treatments 1, 2, 3, 4 and 5, respectively. However, a difference among treatments was statistically similar. The average values of 4% FCM were non-significant.

Garg and Mehta (1998) conducted a trial on twelve pure multiparous HF cows (510-540 kg) 7 to12 days after calving which were divided into two groups of 6 each, to study the effect of bypass fat on feed intake. The cows in experimental group were fed 500g bypass fat daily in the morning, along with the cattle feed. Animals in both the groups were offered same quantity of green jowar or maize or oats or cowpea fodder and were allowed free access to urea molasses mineral block licks during experimental period. Total DMI in both the groups was statistically similar. Feeding of bypass fat @ 500g/cow/day resulted in significantly (P<0.05) higher milk yield in experimental cows. The 4% FCM were significantly higher in treatment group. The initial body condition score of 1.0 of the experimental cows was changed to 0.5 in control and 1.5 in experimental cows at the end of trial period, indicating that cows in control group lost more body weight.

Garg *et al.* (2002) divided twenty crossbred cows into two groups of 10 each, based on milk yield (10-12 kg/day), fat % and stage of lactation. All cows were fed similar basal ration, comprising 15 kg green maize fodder and 5 kg jowar straw. Animals in experimental group were fed 100g bypass fat supplement. The milk yield was 9.8-12.0 kg/d and 11.3-13.0 kg/d for control and bypass fat supplemented group, respectively which was statistically ($P<0.05$) similar among experimental group.

El-Hafeez *et al.* (2002) studied the effect of protected fat on milk yield and composition, digestibility, and some biochemical parameters in low producing cows. Five successive feeding trials, each of 21 days, were performed on ten multiparous hybrid cows, as a group, to study the effect of supplemental dietary fat on yield of milk and its fat content in addition to some biochemical parameters. Rumen-inert fat in the form of Ca salts of fatty acids was added to a basal control diet in trials 2 and 4, at the rate of 400 g per cow daily, forming the fat-supplemented diet. In the other 3 trials (1.3 and 5) a control diet of 14% CP and 1.52 Mcal NE/Kg DM was fed without fat addition. The results showed that fat adding had no negative effect on DM intake, digestibility and characteristics of ruminal fermentation except in trial 2 the first time of fat addition. There was a significant increase in serum total cholesterol and HDL-cholesterol in fat supplemented groups. A highly elevated level of serum triglycerides was observed, leading to increase in milk fat %. The increase in energy density and consequently its intake in fat-supplemented diets were translated in the improved milk and fat production. Conclusively, adding fat at the rate of 400g/animal for 3 weeks alternated periods of unsupplementation increased the milk yield and fat % by about 10% and 0.4 fat percent unit during the fat-feeding periods and 3% and 0.06 fat percent unit during the rest periods, respectively.

Sarwar *et al*. (2003) carried out a study to see the effect of Bergafat T-300, a bypass fat, on the production and composition of milk, four primiparous crossbred cows in their early lactation were used in a 4×4 Latin Square Design. Each period was of 30 days including 15 days of adjustment period. The diets were formulated to contain 0, 2.5, 3.5 and 4.5% of Bergafat. The intake of DM, OM, CP, NDF, and ADF were not affected, however, the EE intake was increased by the supplementation of Bergafat in the diet of cows. The digestibility of NDF and ether extract remained unaffected, whereas the digestibility of DM, OM and CP were reduced. Milk yield remained unaltered, while 4%FCM yield increased as a result of adding Bergafat in the daily ration. Bergafat upto 4.5% of the diet DM can be added in the diet of crossbred cows without any adverse effect on the DM intake and digestibilities of DM and NDF. Furthermore, Bergafat does not cause any butter fat depression in the milk of cows.

Mishra *et al.* (2004) carried out a study on twelve multiparous lactating crossbred cows (360±6.5 kg BW and 6.5±0.3 kg milk/d, 100 days post partum) divided into three groups of four animals each to know the effect of supplementation of calcium salts of mustard oil fatty acids and heat treated crushed mustard seed on DMI. The cows in group I were fed wheat straw with Berseem and conventional concentrate as per NRC (1989). Whereas those, in II and III group were fed the same roughage plus concentrate II and III containing Ca salt of mustard oil and heat treated crushed mustard seed, respectively to provide 4%, 12.8% supplemental fat of ration for 120 days. They observed that DMI (kg/d) was 9.2, 10.2 and 9.6 for groups The DMI and milk yield was significantly higher in group II, as compared to I and III group. The milk fat content was increased by 15.7 and 23.3% in group II and III over group I. They also observed significant ($P<0.05$) increase in SNF%, FCM and milk total solids content in group II and III.

Vidhate *et al.* (2006) studied the economic impact of by-pass fat in cross bred cows. Eighteen cows (J x Local and H.F. x Local) were divided into three groups of six animals each as Group A (with no by-pass fat), Group B (with 100 grams of by-pass fat per day per animal) and Group C (with 150 grams of by-pass fat per day per animal). The initial fat percent of the milk was 3.67, 3.48 and 3.53 per cent for A, B and C groups, which increased to 4.09, 4.11 and 4.45 per cent, respectively at the end of the feeding trial period. Though the milk production was decreased, proportionate increase in fat content exhibited additional benefit of ₹18.21 per animal per day by feeding by-pass fat @150g/day.

Raiker and Thakur (2007) studied the effect of ration fortified with Ca salt of acid oil fatty acid for milk production and composition in buffaloes. Twelve Murrah buffaloes (7.08 and 6.92 kg/d milk yield; 30.5 and 31.5 days in milk) were divided into two groups six in each group and fed concentrate, wheat straw and green maize fodder in 50:15:35 proportion on DM basis (control group) and same ration as of control group plus Ca salt of acid oil fatty acid supplemented at 4% of DMI to experimental groups. Milk yield and 4% FCM yield were 9.49 and 11.86 kg in control group increased to 12.54 and 13.41% in experimental group over 120 days. Thus, it was concluded that supplementation of Ca salt of acid oil fatty acid to buffaloes during early lactation improved milk yield and FCM yield.

Andersen *et al.* (2007) carried out a study on Danish Holstein dairy cows, divided into three groups (n=15) supplemented with control diet, dry high saturated fat (dry HSF) and high linseed diet (dry HUF) from 8 weeks prepartum by. The prepartum DMI was 11.0, 9.4, 9.9 kg/d, and postpartum DMI was 18.3, 18.1, 17.5, kg/d, in respective groups. DMI was found statistically similar in all treatment groups.

Tyagi and Thakur (2007) carried out an experiment on nineteen crossbred cows allotted to two dietary treatments to study the effect of feeding bypass fat on DMI. The distribution of nine animals to group 1 (control diet) and ten to group 2 (control diet + 2.5% bypass fat of DMI) was made on the basis of Most Probable Production Ability (MPPA) and lactation number. The cows under group 2 were fed 2.5% bypass fat. The DMI was found to be 13.84 and 14.18 kg under group 1 and 2, respectively and the difference between the groups was statistically non-significant. The average daily FCM yield was 17.47 and 19.26 kg in group 1 and in group 2, respectively, which was higher ($P<0.05$) by 10.25% in group 2 than that of control group. The results indicated that the average gross milk compositions viz. percents of TS (11.79 and 11.95%) fat (3.99 and 4.27) SNF (7.81 and 7.69) Protein (3.15 and 3.14) and Lactose (4.86 and 4.84) percent in T_1 and T_2 group, respectively were statistically similar. The feed conversion efficiency in terms of DMI (kg/kg milk yield) 0.81 and 0.78, DMI (kg/kg FCM) 0.82 and 0.76, CPI (kg/kg milk yield) and CPI (kg/kg of FCM) 0.12 and 0.11. Similarly, TDN (kg/ kg milk yield) and TDN (kg/kg of FCM) 0.52 and 0.5. The feed conversion efficiency was statistically ($P<0.05$) higher in treatment group than control group.

Sirohi *et al.* (2007) conducted a trial on fifteen lactating Sahiwal cows. The cows were divided into three groups of five each on the basis of milk yield, lactation stage and body weight. The animals under group I were fed - concentrate mixture + green fodder + wheat straw (control diet); the animals under group II were fed control diet + extra 200g/day bypass fat of palm oil and the animals under group III were fed control + extra 200g/day bypass fat of palm oil, respectively. They observed that the DMI was 11.15, 13.65 and 13.58 kg/d for group I, II and III, respectively which was statistically higher in II and III group.

Moallem *et al.* (2007) divided fifty three dry multiparous cows into four treatment groups T_1: Control, T_2: control + 500g/d Propylene glycol (PGYL) per cow until 21 days in milk, T_3: Control + 230 g/d Prilled fatty acids (PrFA) per cow until 100 DIM and T4: Control + 215 g/d CaLFA until 100 DIM. Prepartum DMI was lower in the PrFA and CaLFA groups than in the control and PGLY groups, whereas postpartum DMI in the PrFA group was higher than that in the control group The respective milk yield was 42.3, 42.7, 44.4, 44.3 kg/d which was significantly ($P<0.05$) higher in T_3 and T_4 group. Significant ($P<0.05$) increased in milk yield in PrFA and CaLFA supplemented group. The data suggested that supplementation of prilled fat or CaLFA did not improve the milk fat (3.7, 3.65, 3.52, and 3.65%). However, milk protein (3.09, 3.07, 2.94 and 2.91) and lactose percent (5.10, 5.06, 5.03, 4.97) were significantly ($P<0.05$) higher in control group than treatment group. The respective gross efficiency of FCM production per kg DMI was 1.77, 1.77, 1.83 and 1.88 kg for control, PGLY, PrFY and CaLFA. The efficiency of FCM production was higher ($P<0.05$) in CaLFA group than in control and PGLY groups.

Mosley *et al.* (2007) studied the effect of optimum feeding level of fatty acids of palm oil on milk production in eighteen lactating cows. The four diets were design to provide 0, 500, 1000, and 1,500 g of palm oil per day. Milk yield was 30.9, 34.0, 34.2, and 34.2 kg/d when palm oil was fed at 0, 500, 1000, and 1,500 g levels, respectively. The addition of palm oil @ 500 g increased ($P<0.05$) milk yield. Milk fat percentage was increased from 3.44% for 0 g to 3.95% across all levels of palm oil but there were no differences among levels of palm oil treatments.

Lounglawan *et al.* (2008) carried out an experiment on twenty four lactating Holstein Friesian cows in mid lactation; averaging 20.5±2.7 kg of milk randomly allocated into two treatment groups to determine the effect of feeding rumen-protected fat on dairy cows performance. All cows were fed approximate 10 kg of concentrate mixture together with *ad libitum* grass silage and free access to clean water. DMI was similar among the experimental groups. Nil or 300 g of hydrogenated fat or Ca-salt of fatty acids was supplemented to the cows according to treatment groups. The milk yield, fat, protein, lactose, solids- not-fat and total solids percentage were statistically similar.

Purushothaman *et al.* (2008) divided twenty lactating crossbred cows yielding 10 to 15 litres of milk daily in their mid lactation into four groups of five animals to assess the effect of feeding calcium soaps of palm oil fatty acids on milk yield. The cows in groups 1 (control), 2, 3 and 4 were fed concentrate mixture containing 0 (no bypass fat), 2, 4 and 6% bypass fat, respectively. The average dry matter intake was non-significant between experimental groups. The average milk yield of the cows in group 3 (4% bypass fat) showed a significantly ($P<0.05$) higher than cows of groups 1 2 and 3. Milk fat, protein, SNF and total solids showed a non-significant difference between different treatments group.

Bhosale (2009) conducted a trial on twelve lactating buffaloes which were divided into two groups of six animals each. The group I served as control and group II served as treatment group. Both the group were fed similar concentrate as per the practice of farm while the treatment group received additional supplement of bypass fat @ 100 gm/animal/day. It was observed that the average milk yield was significantly higher in treatment group (12.00 kg) as compared to (10.95 kg) in control group. The FCM yield was higher in treatment group (18.72 kg) as compared to control (16.64 kg). Milk protein, SNF and total solids showed significant increase in treatment group. A net profit of ₹ 33.92/- per buffalo was recorded during the experiment.

Naik *et al.* (2009) conducted a field trial to study the effect of supplementation of rumen protected fat (PF) on lactation response in crossbred dairy cows. Fifteen high yielding crossbred cows were randomly divided into 3 groups, each having five animals. Animals from all the groups were supplemented with similar ration, while the second (T_1) and third group (T_2) were fed an additional supplement of 200 gm rice bran fatty acid oil and 200 gm bypass fat respectively. There was consistently higher milk yield (MY) and 4% fat corrected milk yield in the bypass fat supplemented group over the control and T_1 group throughout the lactation period. During early lactation, the milk yield increased by 3.2 kg/day (19.6%) and the FCM yield increased 2.8 kg/day (22.3%) in the bypass fat group over the control. The milk composition (fat, SNF, protein and lactose) remained similar among the control and T_1 groups. Due to supplementation of bypass fat, there was a net profit of ₹ 34.50 /cow/day over the control group during early lactation.

Parnerkar *et al.* (2010) conducted a farm trial of 120 days under AICRP in Gopalpura village, Anand district conducted by to study the effect of feeding bypass fat to lactating buffaloes. Twelve buffaloes yielding about 8-10 kg milk/day were divided into 2 groups. The buffaloes under T_1 group were fed as per the farm feeding schedule. The buffaloes in experimental group (T_2) were fed in addition bypass fat @ 20g/kg milk yield/day. The 6% FCM in T_1 and T_2 group was 7405.80±113.99, 8450±100.27 kg, respectively, during 120 days. The average yield of whole milk and 6% FCM, in T_1 and T_2 group was 11.17 ± 1.20 and 12.04

± 0.90 and 14.00±1.45 and 16.13±1.28 kg, respectively, which was higher in bypass fat supplemented group, during 90 days.

Sirohi *et al*. (2010) conducted a trial on ten lactating crossbred cows which were divided into two groups on the basis of milk yield (14-15 kg/ day). Each group received similar ration as per the practice of farm while the treatment group received an additional supplement of bypass fat @ 300 gm/day/animal. The average milk yield was significantly higher for treatment group (13.18 kg), as compared to (11.40 kg) in control group. The fat percentage was also higher in treatment group (4.86%) as compared to (4.37%) in control group. The average dry matter intake was statistically non-significant between control (12.54 kg) and treatment (13.60 kg) groups. The digestibility co-efficient was almost similar for all nutrients except for ether extract which was higher in treatment group (85.24%) as compared to control (75.37%). The average FCM yield kg/day was higher in treatment group (14.89) as compared to (12.01) in control. Milk protein and SNF were statistically similar between both the groups.

Bhanderi *et al.* (2011) conducted a trial on twenty four crossbred cows yielding 8-14 kg milk/head/day. The treatments were T_1: basal diet, comprising 25 kg green fodder, and 3-4 kg wheat straw and concentrate as per the requirement (control), T_2: Control + daily 100 g bypass fat/animal and T_3: Control+100 g bypass fat; 10 g rumen protected choline. The average daily milk yield per animal was 10.01, 11.49, 11.78 kg/d respectively which is statistically (P<0.05) higher by 1.48 and 1.77 kg in group II and III respectively. They observed that the DMI in three treatment group was 14.05, 13.80, and 13.70 kg/d respectively. The DMI in all the treatment groups was statistically similar. The average daily milk fat % and T.S % was 3.60, 4.14, 4.21 and 12.54, 13.16, 13.11 respectively which was statistically (P<0.05) higher in T_2 and T_3 groups.

Han *et al*. (2011) carried out a study to investigate the effect of palm oil by-pass Fat (POBF) on milk composition of early lactation Holstein during dry season, 24 postpartum Holstein (1 d-14 d) were selected and align to two groups according to CRD experimental design; each group included 12 Holstein cows. The control received by-pass fat 0 g/h.d, the experimental group received by-pass fat 300 g/h.d. DMI and yield of milk did not be affected with supplementation of bypass fat, however, milk protein increased by 6.71%, milk fat increased by 8.16%, lactose increased by 0.22%, SNF increased by 1.98%, total solids increased by 4.08%; digestibility of diet protein decreased by 6.62%, digestibility of ether extract decreased by 7.96%, digestibility of NDF and ADL decreased by 1.36%, 8.97% respectively, digestibility of DM and OM decreased by 4.42, 3.07 percentage units; amount of C4-C17 milk fatty acids showed a decreased tendency, that of C18-C22 showed an increased tendency, the milk CLA increased significantly (P < 0.01). To sum up, supplementation of by-pass fat for early lactation Holstein is an important measure to balance energy and sustain milk yield and quality.

Zhang *et al.* (2011) carried out a trial to evaluate the effect of dietary fat supplementation on milk components and blood parameters of early-lactating cows under heat stress. Cows in group 1 were fed basal diet without dietary fat (T_1) supplementation (control). The other four experimental groups were fed 1.5% palmitic acid (T_2), rapeseed oil (T_3) or soybean oil (T_4), and 1.8% fat powder (T_5), respectively. The results showed that the average Temperature Humidity Index

(THI) was 76.68. The Dry Matter Intake (DMI) was not affected by fat supplementation, but the milk yield increased for cows fed supplemental fat. Milk fat increased significantly by fat supplementation (P<0.05), while milk protein and lactose were not significantly altered by fat supplementation (P>0.05). These results indicate that supplementation of dietary fat on early-lactating cows during hot weather can alter milk components.

Shelke *et al.* (2011[a]) conducted a study on murrah buffaloes to see the effect of rumen protected fat and protein during prepartum stage. Eighteen buffaloes were selected which were divided into two groups, each having nine animals. Buffaloes in Group 1 (control group) were fed chaffed wheat straw, chopped green maize fodder and concentrate mixture as per requirements; buffaloes in group 2 (treatment group) were fed same ration as control group plus 2.5% rumen protected fat (on DM intake basis) and concentrate mixture containing formaldehyde treated mustard and groundnut oil cake in place of normal mustard and groundnut oil cakes. Buffaloes in group 2 were supplemented rumen protected fat and protein for a period of 60 days prepartum. Average DM intake was 11.13 and 11.69 (kg/d) in groups 1 and 2, respectively, which was significantly higher in group 2. The average CP and TDN intakes were higher in group 2 than that of group 1.

Shelke *et al.* (2011[b]) conducted a study on murrah buffaloes to see the effect of rumen protected fat and protein during prepartum and postpartum stage. Eighteen buffaloes were selected which were divided into two groups, each having nine animals. Buffaloes in Group 1 (control group) were fed chaffed wheat straw, chopped green maize fodder and concentrate mixture as per requirements; buffaloes in group 2 (treatment group) were fed same ration as control group plus 2.5% rumen protected fat (on DM intake basis) and concentrate mixture containing formaldehyde treated mustard and groundnut oil cake in place of normal mustard and groundnut oil cakes. Rumen protected fat and protein was supplemented 60 days prepartum to 90 days postpartum. DMI was similar in both groups, however, average CPI was higher (P<0.05) in group 2 (2.03 kg/d) than in group 1 (1.75 kg/d). The average TDN intake was higher (P<0.01) by 16.05 per cent in group 2 (10.12 kg/d) than in group 1 (8.72 kg/d). The average milk yield (210 d) was higher (P<0.05) by 16.84 per cent in group 2

(11.93 kg/d) than in group 1 (10.21 kg/d). Similar trend was observed in 6% FCM yield in both the groups. Net return over feed cost of milk yield per animal per day in control and treatment group was Rs.177.50 and 210.01, respectively. Similarly, net return over feed cost of 6% FCM yield per animal per day in control and treatment group was Rs.177.45 and 224.36. These results indicated that feeding of rumen protected fat and protein to high yielding lactating buffaloes during early lactation was cost effective.

Kumar *et al.* (2012) carried out a trial on twenty lactating Holstein Friesian cross bred cows with more or less similar milk yield, same parity and in early lactation phase were selected and divided into four groups with five cows each. The body weight was 450±30 kg. The feed ingredients and fodder offered to them was unchanged during the period of trial and test group was offered bypass fat supplement at 100g, 200g and 300g once in a day per cow. During the first week the average milk production per day ranged from 92±0.51 kg (control group) to 100±0.32 kg (test group) and fat percentage from 3.96±0.08 to 4.42±0.04, in the second week the production ranged from 93±0.40 to 103±0.25 kg and fat percentage from 3.86±0.06 to 4.40±0.07, in the third week the production ranged from 90±0.63 to 102±0.25 kg and fat percentage from 3.88±0.04 to 4.38±0.04, in the fourth week the production ranged from 97±0.40 to 106±0.38 and fat percentage from 3.84±0.04 to 4.54±0.02, in the fifth week the production ranged from 94±0.38 to 105±0.45 kg and fat percentage from 3.98±0.06 to 4.62±0.04, in the sixth week the production ranged from 91±0.73 to 101±0.20 kg and fat percentage from 3.84±0.02 to 4.48±0.04, in the seventh week the production ranged from 98±0.51 kg to 107±0.68 kg and fat percentage from 3.94±0.05 to 4.58±0.04, in the eighth week the production ranged from 93±0.25 to 108±0.51 kg and fat percentage from 4.06±0.02 to 4.60±0.03 respectively. It was concluded that supplementation of rumen protected fat in cross bred cows during early lactation significantly increased milk yield and milk fat percentage.

Shelke *et al.* (2012) studied the effect of feeding bypass fat and bypass protein during 60 days prepartum and 90 days postpartum in murrah buffaloes. They conducted experiment on eighteen Murrah buffaloes dividing into two groups containing nine animals each. Buffaloes in control group (C group) were fed chaffed wheat straw, chopped maize fodder and concentrate mixture as per stipulated requirements. Buffaloes in supplemented group (S group) were fed same ration as C group plus 2.5% rumen protected fat (on DMB) and formaldehyde treated mustard and groundnut oil cake in place of unprotected cakes. Buffaloes in Group S were supplemented with both rumen protected fat and protein 60 days pre-partum to 90 days postpartum and persistence of milk production was monitored up to 210 days of lactation. Milk yield during supplementation period (90 days) in S group was 13.11 kg/d and was 19% higher ($P<0.01$) than the C group (11.01 kg/d. There was no effect on total solid, protein, solid-not fat (SNF) and lactose contents in the two groups, whereas milk fat yield was increased significantly.

Mudgal *et al.* (2012) conducted an experiment on twelve crossbred cows (milk production 6.52±1.15 liters) in late lactation (150±10 days in lactation) to know the effect of berga fat on DMI. Cows were divided into two groups of six each on the basis of their production and control group was fed basal diet of concentrate mixture and *ad libitum* wheat straw, while the treatment group was supplemented with 200 g berga fat/head/day in addition to same basal diet. The data suggested that feeding of bypass fat had no significant effect on dry matter intake and milk yield.

Wadhwa *et al.* (2012) fed fifteen crossbred cows in early lactation, producing more than 10 kg milk/d into 2 equal groups to assess the effect of strategic supplementation of bypass fat (BPF) on the performance of high yielding crossbred cows. The treatments consist of control group (C) who offered home-made concentrate mixture as per requirement and non-leguminous green fodder for 180 days. The animals in the experimental group were offered *ad libitum* control diet along with 150-200 g BPF i.e. calcium salts of rice bran fatty acid oil. The average daily milk yield was improved by 1.13 kg/d (21.55 vs. 20.42 kg/d) in BPF supplemented group as compared to control which was statistically ($P<0.05$) higher in treatment group. The respective protein, SNF, lactose and fat % were statistically similar.

Desai (2012) conducted a trial on eighty buffaloes in their second to fourth lactation (15-60 d post-partum) which were selected for on-farm trial of 90 d duration at tribal villages of Panchmahal and Vadodara district under the project of AICRP. The buffaloes were selected on the basis of their average daily milk yield and fat percent and were randomly allotted to two dietary treatments i.e. T_1 (Control) fed with Home-made concentrate mixture + Green fodder + Dry fodder and T_2 Control diet along with bypass fat @ 15 g/kg milk yield. The DMI in both the group was 11.30±0.04 and 11.49±0.15 in T_1 and T_2 groups in Panchmahal district, respectively and in Vadodara district 11.28±0.08 and 11.42±0.18 kg/head/d in T_1 and T_2 groups, respectively. The DMI in both groups and in both the district was found statistically similar. Milk yield in Panchmahal and Vadodara district was 5.98**±**0.12 and 6.52**±**0.09; 6.47**±**0.20 and 6.88**±**0.09; in T1 and T2, respectively, similarly 6% FCM in same district was found to be 8.89±0.15 and 10.13±0.12 and 9.89±0.31 and 10.82±0.16 which was significantly (P<0.01) higher in bypass fat supplemented group. The respective fat yield and SNF were 0.41**±**0.01 and 0.48**±**0.01; 0.55±0.01 and 0.58±0.01; respectively and in Vadodara district 0.46**±**0.01 and 0.52±0.01; 0.60±0.02 and 0.61±0.01; in T_1 and T_2 groups respectively**.** The fat yield and SNF was significantly higher in bypass supplemented group than control. In Panchmahal district the feed conversion efficiency in terms of DMI (kg/kg whole milk), CPI (g/kg whole milk) and TDNI (kg/kg whole milk) 1.92±0.03 and 1.78±0.02; 220.76±3.15 and 201.84±2.66 and 1.10±0.02 and 1.03±0.01 respectively, in T_1 and T_2 groups while in Vadodara 1.77±0.04 and 1.68±0.03; 219.69±3.64 and 195.63±2.89 and 1.05±0.02 and 0.98±0.02 districts was superior (P<0.01) in bypass fat group. Similar trend was observed in T_1 and T_2 groups in terms of DM, CP and TDN into 6% FCM in Panchmahal (1.73±0.02 and 1.54±0.02 kg/kg; 199.69±2.20 and 173.61±2.06 g/kg and 0.99±0.01 and 0.88±0.01 kg/kg) and Vadodara (1.57±0.04 and 1.43±0.03 kg/kg; 194.56±3.22 and 166.63±2.52 g/kg and 0.93±0.02 and 0.84±0.02 kg/kg) districts.

Dhulipalla *et al.* (2013) conducted an experiment to study the effect of feeding Milk Dhara supplement on milk yield and composition in lactating buffaloes. Twelve multiparous (2nd/3rd lactation) graded Murrah buffaloes (450 ± 25 kg) in mid lactation (3-4 months) were divided into two groups of six animals each (control and treatment). Animals in both the groups received a basal diet comprising of Hybrid Napier, paddy straw and concentrates while the buffaloes in the treatment group were fed same basal diet plus Milk Dhara containing rumen stable bypass fat and protein at 100 g/buffalo/day. Results revealed that milk yield (kg/d) was significantly higher in treatment group (9.33 kg) as compared to control group (9.02 kg), 6% FCM yield (kg/d) and all milk constituents except SNF % increased significantly with addition of supplement containing rumen bypass fat and protein in the diet. Thus, it can be concluded that supplementation of Milk Dhara at 100g/buffalo/day improved milk yield and milk composition in graded Murrah buffaloes.

Patel *et al.* (2013) carried out an experiment on twelve lactating crossbred cows divided into two groups, each group having six animals. Group I (control) and Group II (treatment) and were offered similar feed (concentrate mixture+ green fodder+ dry fodder), while the treatment group was fed with additional supplement of bypass fat @ 10 gm/kg of milk yield. The results of the experiment revealed that the DMI and DCPI were 13.80 and 14.70 kg and 1222 and 1329 gm for control and treatment groups respectively, which were statistically non-significant. TDNI was found statistically higher (P<0.05) in treatment group (9.33 kg) as compared to control (8.39 kg). The milk yield was significantly higher in treatment group (17.78 kg) as compared to control group (15.67kg). Average milk fat percentage was higher in treatment group (0.77 kg/day) as compared to control (0.60 kg/day). Similarly, the value of 4% FCM yield was higher in treatment group (18.55 kg) as compared to control (15.30 kg) in crossbred cows. SNF percentage was higher for treatment group as compared to control.

Ranjan *et al.* (2013) conducted a study to assess the effect of dietary supplementation of rumen protected fat on nutrient utilization and productive performance of lactating murrah buffaloes. Fifteen murrah buffaloes were divided into three equal groups i.e. T_I (control), T_2 and T_3 and were offered similar basal concentrate and roughage ration while the T_2 and T_3 groups were supplemented bypass fat supplement of 100 gm/day and 200 gm/day respectively. The average milk yield of three experimental groups was 4.79, 5.59 and 7.20 kg/day which were statistically non-significant. The average 6.5% FCM yield was significantly higher in T_3 group than T_1. The average milk fat percentage in T_1, T_2, T_3 group were 8.16, 8.22, 8.95 respectively which was statistically non significant. The average values of total solids and SNF were statistically non-significant. However the milk protein was significantly higher in T_3 compared to T_1 group. DM intake was statistically non-significant among experimental groups. DM intake kg/ kg

FCM yeild was lower in T_3 than T_1. The DCP and TDN intake were similar for all the groups.

Vahora *et al.* (2013) conducted a trial to study the effect of feeding bypass fat and bypass protein to buffalo heifers in the Dahod district of Gujarat for a period of 90 days. Forty growing buffalo calves were divided in two groups consisting of one control group (CON) fed with a basal diet without supplementation and other treatment group (BYNUTR) fed with basal diet plus bypass nutrients (extruded soybean meal as bypass protein) @ 200g/head/d and calcium salt of palm oil fatty acids as bypass fat @ 50 g/d. Body weight and measurements were recorded at fortnightly intervals. The economics of feeding was calculated. The results revealed that there were significant (P>0.001) improvement in average daily weight gain in the buffalo heifers of the BYNUTR group compared to CON group. The average milk yield and 6% FCM yield was statistically higher in bypass fat fed groups. Body length, height and heart girth were also increased in the BUNUTR group. Feeding of bypass nutrients decreased cost of feeding per kg live weight gain.

Ansar *et al.* (2014) carried out an experiment on lactating Holstein Friesian cows. Four animals were selected which were divided into two groups of two animals each. The control and treatment group were fed same ration while the treatment group was fed with additional supplement of 200 gm of bypass fat. The results of the experiment revealed that the feed intake (as such basis) was decreased up to 19 kg/day from 20 kg/day in treatment group. The milk yield was found to increase from 14.5 kg/day to 15.00 kg/day while the fat percentage increased from 3.15% to 3.35% in treatment group.

Rajesh *et al.* (2014) conducted an experiment on ten crossbred cows which were divided into five animals each. The cows from both the groups were fed *ad lib.* green fodder (Jowar) and wheat straw during the experimental period, while the treatment group was fed an additional supplement of prilled bypass fat @ 75 gm/day/cow for a period of 30 days prepartum and 150 gm/day/animal during 120 days postpartum. The data from the experiment revealed that the treatment group had significantly higher milk yield than control group (17.04±1.50 kg/d vs. 16.07±2.30kg/d). Milk fat was significantly higher in treatment group as compared to control. Digestibility coefficients of dry matter (DM) were similar in control and treatment group (75.77 and 75.91%). The TDN intake was significantly higher (P<0.05) in treatment group compared to control. Digestibility of EE was higher (p<0.05) in treatment group as compared to control group. Average BCS of cows were more in treatment group (3.11±0.24) than control (2.58±0.24) .The protein and SNF content of milk was similar in both the groups.

Ramteke *et al.* (2014) carried out a trial on twenty four buffaloes (30 days prepartum and 120 days postpartum) to study the effect of feeding bypass fat on productive performance in buffaloes. The buffaloes were divided into two dietary treatments i.e. T_1 (control) and T_2 (bypass fat). The buffaloes in control group (T_1) were fed as per farm feeding schedule (concentrate+ green roughage + dry roughages) and those in bypass fat group (T_2) were fed same as that of control + by pass fat at 100 g/d for 30 days and 15g/kg milk yield per day for 120 days. The DMI during prepartum and postpartum were 8.00 and 7.79 kg/day and 11.42 and 11.41 kg/day in control and treatment group respectively, which were stastically similar in both the groups while DCPI during prepartum was statistically (p<0.01) higher in treatment group while during postpartum phase it was statistically similar in both groups. TDNI was found to be significantly higher in bypass fat supplemented group during both the phases. The average milk yield was significantly higher for treatment group (7.66 kg) as compared to (7.18 kg) in control group. Similarly the fat percentage was higher for treatment group (7.58 %) as compared to (7.27%) in control. The 6% FCM values were higher for treatment (8.84 kg) as compared to control (8.24 kg). The milk SNF reduced in treatment group. The milk total solids were similar between both the groups.

Sontakke *et al.* (2014) conducted a study to observe the effect of feeding rice bran lyso-phospholipids (RBLP) and rumen protected fat (RPF) in 18 crossbred lactating Karan Fries cows. They were randomly allocated to 3 treatment groups having 6 animals each. Group 1 was supplemented with 2.5% mustard oil, group 2 with 6% RBLP and group 3 with 3% RPF in the concentrate mixture. All the cows were given roughage: concentrate mixture (60: 40) ration and roughage comprised of berseem fodder (30%) and wheat straw (30%) as per requirements. The dry matter intake (DMI) averaged 12.14, 11.77 and 11.88 kg/d in groups 1, 2 and 3 respectively, which was non-significant. Milk yield remained unaltered, while 4% fat corrected milk (FCM) yield increased as a result of adding RBLP and RPF due to significant increase in milk fat per cent in groups 2 and 3 cows. The protein, lactose, total solids, and solids-not-fat were non-significant between both the groups.

Yadav *et al.* (2015) carried out a trial on ten crossbred cows divided into two groups, each group having five animals. The animals in control and treatment group group were fed as per the practice of farm while treatment group received an additional supplement of prilled fat @ 75 gm/cow/day from 45 days prepartum till parturition. After parturition the treatment group received prilled fat @ 150 gm/cow/day till day 70 of lactation. The average milk yield of treatment group (14.34 kg) was higher as compared to control (12.90 kg). The average fat percentage was also higher for treatment group (4.71 %) as compared to control (4.22 %). The 4% FCM yield was again higher in treatment (15.65 kg) as compared to (13.06) in control. The body condition score of treatment group was significantly more as compared to control. Milk protein was similar among both the experimental groups while SNF was higher in treatment group.

Thus, the perusal of literature cited above indicates that the bypass fat can be effectively supplemented at different levels to the lactating animals as a feed additive. It also indicated that the supplementation of by-pass fat for dairy animals resulted in improved digestibility, better performance in terms of milk yield and its composition and better nutrient utilization, which is associated with better feed efficiency. The foregoing literature also revealed that the use of by-pass fat in dairy animals is also cost effective, resulting in economical milk production.

3. MATERIALS AND METHODS

The present study was conducted at Manoj Dairy Farm Rahuri, Ahemadnagar and the Department of Animal Nutrition, Bombay Veterinary College, Parel, Mumbai-12. In this experiment, the effect of supplementing bypass fat with concentrate mixture was evaluated in terms of milk production and its composition. The efficiency of feed utilization in terms of DM, DCP and TDN intake per kg FCM yield, body condition score and economics was also studied.

3.1. Experimental Animals:

For this trial, twelve crossbreed Holstein Friesian cows were selected. The animals were selected on the basis of daily milk yield, gestation stage and lactation number. The average daily milk production was 10-11 kg/day/animal and 3-4 lactation numbers. The average stage of pregnancy of selected cows was around 30-35 days before parturition. The selected cows were divided into two groups of six each.

3. 2. Plan and design of experiment:

The selected cows were divided into two groups, viz. I, II of six cow each. The group I served as control and received concentrate mixture routinely used on farm. Group II served as treatment and fed as per control plus supplementation of bypass fat, for a period of 30-35 days before parturition to two months after parturition. During trial period, the observations pertaining to milk yield, milk composition and feed intake were recorded at weekly interval for both the groups. The milk composition was studied in terms of milk protein, fat, total solids, SNF and specific gravity. The week wise efficiency of feed utilization was also calculated in terms of DM, TDN and DCP intake per kg FCM yield. The Body condition score was estimated at fortnightly interval. During last week of the trial, a digestion trial of seven days duration was conducted with total collection method to study the digestibility of various nutrients for both groups. At the end, the economics of milk production was also studied over the feed cost. The experiment lasted for 13 weeks.

3.3. Experimental feeds and feeding schedule:

The experimental groups were randomly allotted to different feed treatments. The details of feed treatments allotted are given below.

Group I (Control): received roughages and concentrate mixture prepared as per the practice of farm.

Group II (Treatment): received roughages and concentrate mixture prepared as per the practice of farm and supplemented with bypass fat @ 30gm/100kg BW.

Conventional practice of feeding concentrates and roughages separately was followed throughout the experiment. The farm procured the feed ingredients from local market in bulk quantities. The concentrate mixture was prepared fresh every day by hand mixing on the farm and kept for soaking in water for 4 to 6 hours and was fed in two instalments i.e. at 3.30 am and 3.30 pm just before milking. The ingredient composition of concentrate mixture was 30 kg ground maize, 32 kg cottonseed cake, 35 kg wheat bran, 2% mineral mixture and 1% salt.

Chopped green Guinea grass (*Megathyrsus maximus*) and Lucerne (*Medicago sativa*) was used as green forage in the experiment for both the groups.

Once in a week the roughage intake was recorded group wise for both the groups. The representative samples of concentrate mixture, dry roughages and greens were collected at weekly interval, oven dried and stored for further analysis. At the end, representative pooled samples were analyzed for chemical composition. The average chemical composition of concentrate mixture, guinea grass and Lucerne is presented in Table 1. Average chemical composition of individual concentrate ingredients is presented in Table 2.

Table 1. Average chemical composition (%DMB) of concentrate mixture, guinea grass and lucerne

Nutrient	Concentrate mixture (soaked)	Guinea Grass	Lucerne
Dry matter	45.22	24	17
Organic matter	95.35	90.89	88.5
Crude protein	15.71	8.60	21.50
Ether extract	5.58	1.52	2.05
Crude fibre	12.38	37	28
N.F.E.	61.68	43.77	36.95
Total Ash	4.65	9.11	11.5
AIA	1.08	3.2	2.4
Calcium	0.85	0.55	2.02
Phosphorus	0.36	0.32	0.30

Table 2. Average chemical composition (%DMB) of concentrate ingredients

Nutrient	Ground maize	Cottonseed cake	Wheat bran
Dry matter	92.77	90.85	91.64
Organic matter	96.16	93.90	93.50
Crude protein	10.56	24	13.90
Ether extract	3.47	10.03	3.81
Crude fibre	2.41	23.86	11.50
NFE	79.74	36.01	64.29
Total Ash	3.82	6.10	6.50
AIA	0.81	1.46	1.34
Calcium	0.062	0.30	0.20
Phosphorus	0.047	0.70	0.78

3.4. Chemical composition of bypass fat: Fat: 85%**,** Calcium: 09%.

3.5. Housing, Management and Health Care:

The experimental animals were housed in ideal sheds with proper ventilation, flooring and tying arrangements. Normal standards of hygiene, management, feeding practices, vaccination and deworming programs were followed for all the experimental dairy cows throughout the experimental period.

3.6. Observations Recorded:

The following observations were recorded during the entire experimental period of 13 weeks:

1) Daily morning and evening milk production of individual animal at weekly interval.

2) Milk samples from individual cows were collected weekly for estimation of specific gravity, percentage of total solids, fat, protein and solids not fat (SNF).

3) Week wise daily intake of concentrate mixture by individual animal was measured for both the groups, offered as per the practice of farm.

4) Daily consumption of green fodder at weekly intervals, common for all the animals of each group.

5) Week wise efficiency of feed utilization in terms of DM, TDN and DCP intake per kg FCM yield was recorded for both the groups.

6) During last week of the experiment, a digestibility trial of seven days duration, by total collection method, was undertaken on four animals from each group.

7) Body condition score was recorded at fortnight interval.

8) At the end, economics of the use of bypass fat supplement was worked out over feed cost.

3.7. Digestibility trial:

In the last week of the experiment a digestibility trial of seven days duration was conducted by total collection method. Four animals from each group were used for the digestibility trial. The animals were tied separately with sufficient space to avoid eating of feed/fodder of each other. During trial period daily intake of the concentrate mixture and roughages was recorded individually. Total quantity of dung voided during 24 hours period by individual animal was recorded. Daily 1/200th part of faeces voided by each animal was oven dried to constant weight for moisture estimation and the pooled dried samples for seven days were used for proximate analysis. Daily 1/400th part of total faecal matter was preserved animal wise for nitrogen estimation. The faecal samples for nitrogen estimation were preserved in sulfuric acid (5% w/v) used at the rate of 10 ml/50 g of faecal sample, and animal wise pooled samples were used for protein estimation.

3.8. Analysis of feed, fodder and milk:

Representative samples of concentrate mixture, green fodder i.e Guinea grass and lucern, used for feeding of animals were collected at weekly interval throughout the experimental period, oven dried and the pooled feed and faecal samples collected during digestibility trial were analyzed. The analysis for proximate principles and phosphorus was undertaken as per A.O.A.C. (2000) and calcium estimation as per Talapatra *et al*. (1940) in the Laboratory of Department of Animal Nutrition, Bombay Veterinary College, Parel, Mumbai - 400012.

The composition of milk in relation to Fat, Protein, Total solids, SNF and Specific gravity were estimated at weekly interval by Akashganga Complete Milk Analyzer (M/s. Shri. Kamdhenu Electronics Pvt. Ltd., Gujarat). The fat corrected (4%) milk yield was calculated by using Gain's formula as per Manual in Dairy Chemistry (1972).

$$FCM = 0.4\ M + 15\ F$$

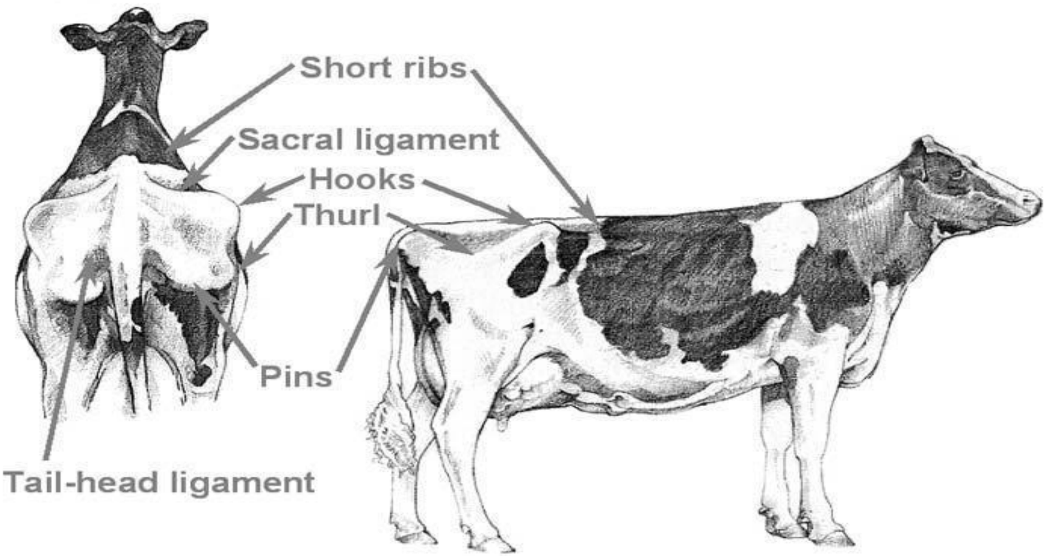
Where, M = Amount of milk actually produced.

F = Amount of fat secreted in that much milk.

3.9. Body Condition Score (BCS):

The animals BCS was recorded at fortnightly interval. Scoring system of 1 to 5 point scale using 0.25 increments for Holstein Friesian cows as per Ferguson *et al*. (1994) and confirmed by Elanco (1997) was used to record BCS of each individual cows .

The system suggested by Ferguson *et al*., (1994) and Elanco (1997) were used owing to its consistency between the score of 2.5 to 4 as well as its frequent use to examine BCS of other breeds. As per the system of scoring following 6 body check points were examined (Figure 1)

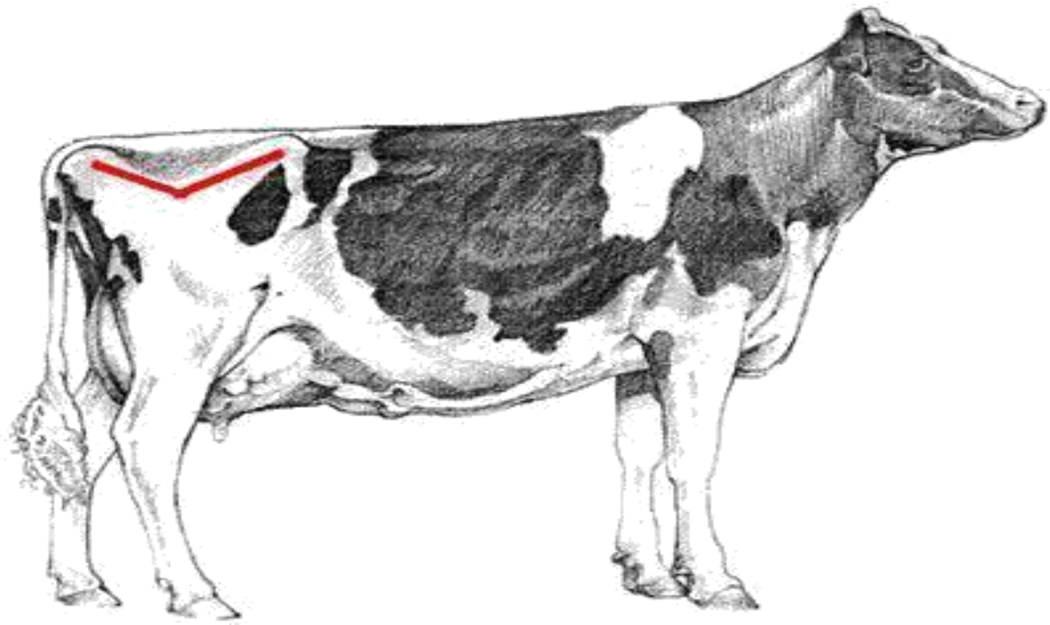


Source: Elanco Animal Health, 1997)

Figure I. Different body check points of cow used for BCS.

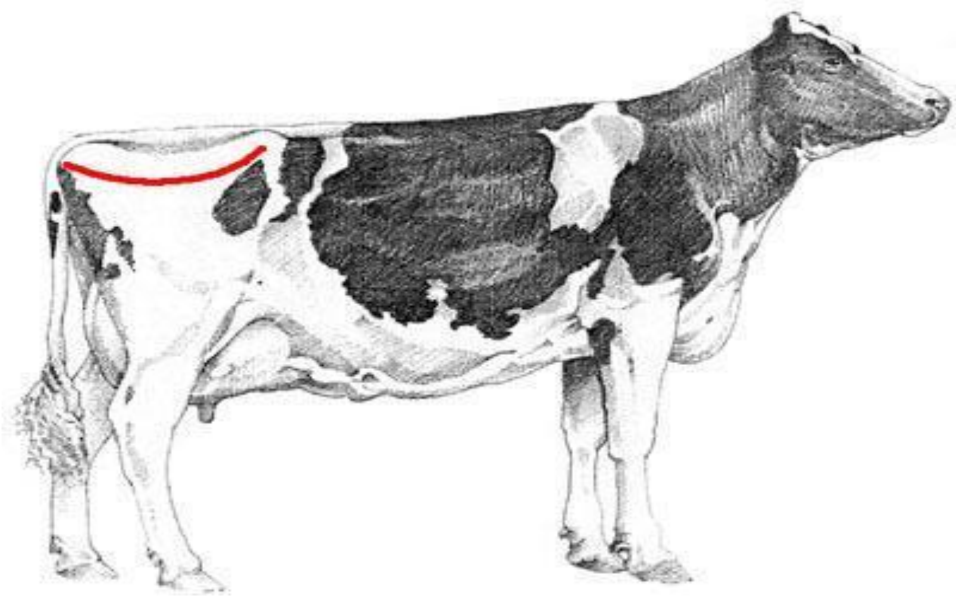
i. Loin (short ribs)
(a) Spinous process and (b) Transverse process
ii. Pin bone
iii. Hook bone
iv. Thurl (Rump)
v. Tail head ligament
vi. Sacral ligament

Procedure of scoring: - The first described step in this system was to determine principle descriptor i.e. rump (thurl). The line drawn from the hook bone to the thurl and to pin bone is angular (V) or crescent (U) (Figure II and III)



(Source: Elanco Animal Health, 1997)

Fig. II The line from the hooks, to the thurl, to the pins forms a flattened V. If the line forms a flattened V then BCS ≤ 3.0.



(Source: Elanco Animal Health, 1997)

Fig. III The line forms a crescent or flattened U. If the line forms a crescent or flattened U consider BCS ≥ 3.25

3.10. Economics:

Group wise average daily total feeding cost per animal was calculated based on the average consumption of concentrate mixture, green fodder and bypass fat separately. Gross returns from sale of milk from both the groups were calculated considering average daily milk production per animal over 8 weeks period and farm selling price of ₹35 per kg of milk. Daily gross profit per cow from both the groups was worked out taking into account, average daily feeding expenses per animal and sale price of milk.

3.11. Statistical Analysis:

Observations of various parameters recorded during experimental period were tabulated and data were statistically analyzed as per Snedecor and Cochran (1994) by using paired ‘ t ’ test.

4. RESULTS AND DISCUSSION

The present study was conducted at Manoj Dairy Farm Rahuri, Ahemadnagar and the Department of Animal Nutrition, Bombay Veterinary College, Parel, Mumbai-12. In this experiment, the effect of supplementation of bypass fat with concentrate mixture was evaluated in terms of milk production and its composition. The efficiency of feed utilization in terms of DM, DCP and TDN intake per kg FCM yield, body condition score and economics were also studied.

4.1. Dry matter intake:

The week wise average daily dry matter intake of cows from both the experimental groups during prepartum and postpartum is presented in Table 3 and 4 respectively, the same is presented graphically in Figure IV and V.

It is observed from the data that the average daily dry matter intake of prepartum and postpartum cows ranged from 7.14 kg to 8.85 kg and 8.08 kg to 12.18 kg respectively. The average daily dry matter intake of prepartum cows from control and treatment group were 8.37 kg and 8.40 kg, respectively. The average daily dry matter intake of postpartum cows from control and treatment group was 10.12 kg and 10.31 kg, respectively.

The week wise average daily dry matter intake data were subjected to statistical analysis by using paired 't' test. The result indicated that the average daily dry matter intake of prepartum and postpartum cows from control and treatment group was statistically non-significant. The dry matter intake of treatment group in present study was numerically slightly higher than control although statistically non-significant, indicating that the palatability of concentrate mixture was not affected due to the supplementation of bypass fat. Going through review of literature in some experiments it was observed reduced dry matter intake after supplementation of bypass fat, which may be due to unacceptable smell which affected the palatability of the feed.

The results of the present study are in agreement with Yadav *et al.* (2015) who reported non-significant effect on dry matter intake between control and treatment group supplemented with prilled bypass fat @ 75 gm/day/animal during prepartum and 150 gm/day/animal during postpartum stage in crossbred cows. Sontakke *et al.* (2014) reported statistically non-significant dry matter intake among control and treatment group in lactating crossbred cows supplemented with 3% rumen protected fat in lactating crossbred cows. Patel *et al*. (2013) also reported non-significant difference in dry matter intake between control (13.80 kg) and treatment (14.70 kg) group in lactatings crossbred cows supplemented with bypass fat. Mudgal *et al.* (2012) observed statistically non-significant effect of supplementation of bypass fat on dry matter intake among treatment and control goup in crossbred cows. Similar observations were reported by Garg and Mehta (1998), Sarwar *et al.* (2003), Anderson *et al.* (2007), Tyagi and Thakur (2007), Lounglawan *et al.* (2008), Purshothaman *et al.* (2008), Sirohi *et al.* (2010), Bhanderi *et al.* (2011) and Zhang *et al.* (2011) in crossbred cows.

Ramteke *et al.* (2014) recorded statistically non-significant effect on DMI in buffaloes in prepartum and post partum stage by feeding bypass fat @ 100 gm prepartum and 15 gm/kg milk yield/day for 120 days postpartum. Ranjan *et al.* (2013) found no infuence of supplementation of bypass on DMI in lactating buffaloes. Similar observations were reported by Desai (2012) and Shelke *at al.* (2011b) in lactating buffaloes.

Contrary to the findings of present study Ansar *et al.* (2014) observed reduced dry matter intake in treatment group in crossbred cows. Han *et al*. (2011) also reported lower dry matter intake in treatment group (12.87 kg) as compared to control (13.08 kg) in crossbred cows. Similar observations were reported by Schauff and Clark (1992) and Moallem (2007) in cross bred cows. While Sirohi *et al.* (2007) and Mishra *et al.* (2004) reported statistically higher dry matter intake in treatment group than control in crossbred cows.

Shelke *et al.* (2011) reported higher dry matter intake during prepartum stage in buffaloes supplemented with bypass fat. Bhosale (2009) also observed statistically higher dry matter intake in treatment group supplemented with bypass fat @ 100gm/day/animal compared to control group in lactating buffaloes.

Table 3. Weekly average daily dry matter intake (kg) of prepartum cows from both groups

Week	Control	Treatment
1	8.82	8.85
2	8.76	8.75
3	8.65	8.67
4	8.49	8.50
5	7.14	7.22
Average ± SE	**8.37±0.313**	**8.40±0.300**

NS- Non significant

Figure IV. Weekly average daily dry matter intake (kg) of prepartum cows from both groups

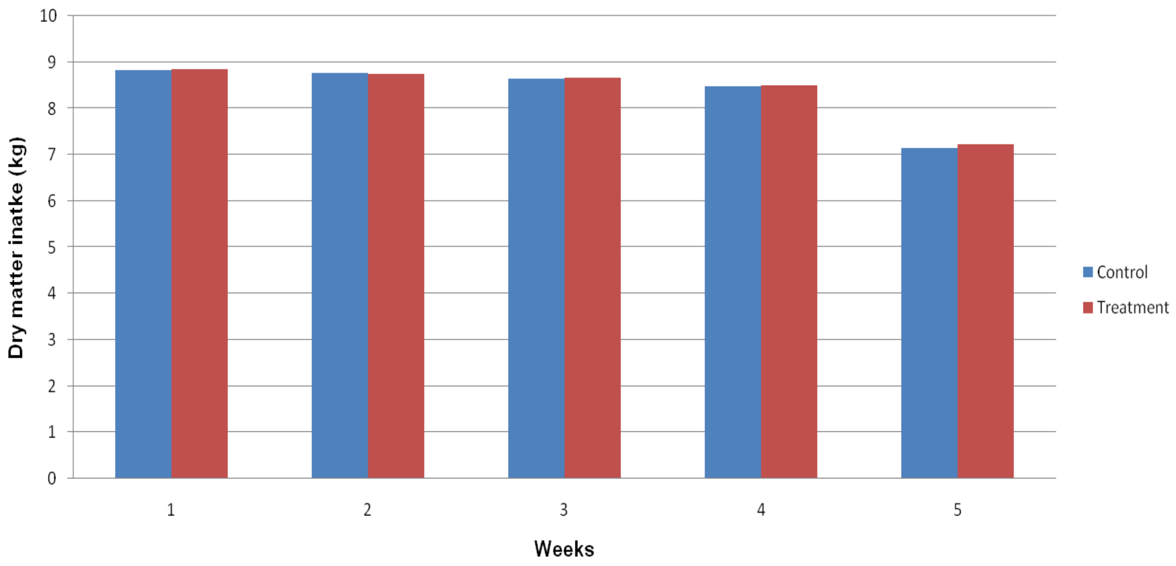


Table 4. Weekly average daily dry matter intake (kg) of postpartum cows from both groups

Week	Control	Treatment
1	8.08	8.27
2	8.66	8.95
3	9.29	9.65
4	9.84	10.25
5	10.54	10.72
6	10.77	11.24
7	11.60	11.50
8	12.18	11.91
Average ± SE	**10.12±0.502**	**10.31±0.0452**

NS- Non significant

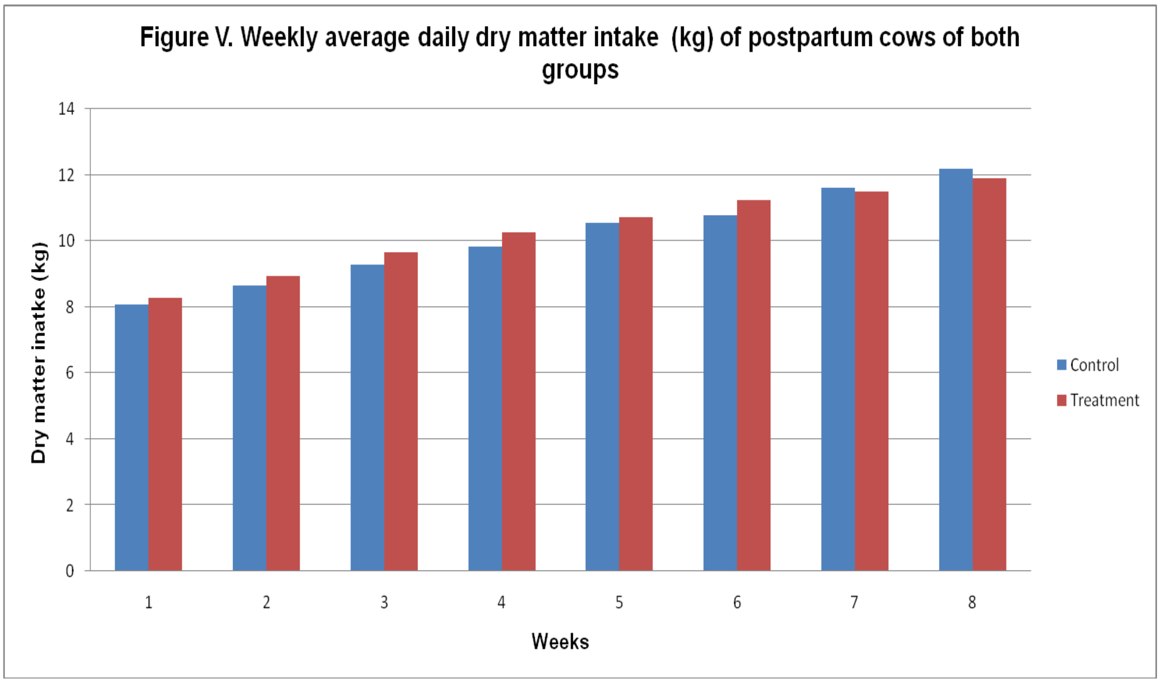


Figure V. Weekly average daily dry matter intake (kg) of postpartum cows of both groups
Dry matter inatke (kg)
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
Weeks
Control
Treatment

4.2. Milk Yield:

The weekly average daily milk yield of both groups is presented in Table 5, and the same is depicted graphically in Figure VI. It is observed from the data that the daily average milk yield ranged from 12.51 kg to 19.48 kg in the experimental animals. The average daily milk yield of cows from control and treatment groups was 15.11 kg and 16.50 kg, respectively.

The weekly average daily milk yield data were subjected to statistical analysis by using paired 't' test. The result indicated that the average daily milk yield of cows from treatment group was significantly ($P<0.01$) higher than control group. This suggested that feeding of bypass fat in lactating cows is beneficial in increasing milk production. The higher milk yield in bypass supplemented cows may be due to higher ME intake through rumen protected fat. The other reason for increase in milk yield may be due to increase in the composition of digestible nutrients in treatment group which was revealed from digestion trial, could have a positive effect on lactational performance of animals.

These results correlate with the findings of Yadav *et al.* (2015) who reported higher milk yield in treatment group (14.34±0.16 kg) than control group (12.90±0.19 kg) in crossbred cows supplemented with prilled bypass fat @ 150 gm/day/animal. Rajesh *et al*. (2014) found that the treatment group (prilled bypass fat @ 75 gm/day/cow) had significantly higher milk yield than control group (17.04±1.50 kg/d vs. 16.07±2.30kg/d) in crossbred cows. Ansar *et al.* (2014) observed increase in the milk yield after supplementation of bypass fat @ 200 gm/day/animal. Patel *et al*. (2013) also reported statistically higher milk yield in treatment group (17.88 kg) than control (15.67 kg) in crossbred cows. Sirohi *et al.* (2010) concluded that the average milk yield in bypass fat supplemented group was 13.18 kg as compared 11.40 kg in control group, in lactating crossbred cows Similar results were reported by Schneider *et al.* (1988), Canale *et al.* (1990), Mishra *et al.* (2004), Purshotaman *et al.* (2008), Naik *et al.* (2009), Parnerkar *et al*. (2009), Zhang *et al*. (2011) and Wadhwa *et al*. (2012) in crossbred cows.

Ramteke *et al.* (2014) reported that the average milk yield was significantly higher in buffaloes of treatment group (7.66 kg) as compared to n control group (7.18 kg).. Dhulipalla *et al*. (2013) reported higher milk yield in buffaloes supplemented with bypass fat @100 gm/day/animal compared to control group. Similar results were also reported by Raikar and Thakur (2007), Bhosale (2009), Shelke *et al.* (2011b), and Desai *et al.* (2012) in lactating buffaloes.

Contrary to the present study, Sontake *et al.* (2014) reported statistically non-significant effect of supplementation of bypass fat on milk production in crossbred cows. Han *et al.* (2011) found that the milk yield was not affected with the supplementation of bypass fat @ 300 gm/day/animal in Holstein cows. Similar results were reported by Lounglawan *et al*. (2008) and Sarwar *et al.* (2003) in crossbred cows. While Schauff and Clark (1992) reported lower milk production in cows supplemented with bypass fat @ 9% as compared to 3 and 6% respectively.

Ranjan *et al*. (2013) reported non-significant effect of bypass fat on milk yield in Murrah buffaloes.

Table 5. Weekly average daily milk yield (kg) of cows from both groups

Week	Control	Treatment
1	12.51	13.38
2	13.36	14.25
3	14.10	15.13
4	14.79	16.08
5	15.47	17.00
6	16.29	17.89
7	16.90	18.76
8	17.47	19.48
Average ± SE	**15.11±0.616**	**16.50±0.768**

Significant t_{14} $P < 0.01$

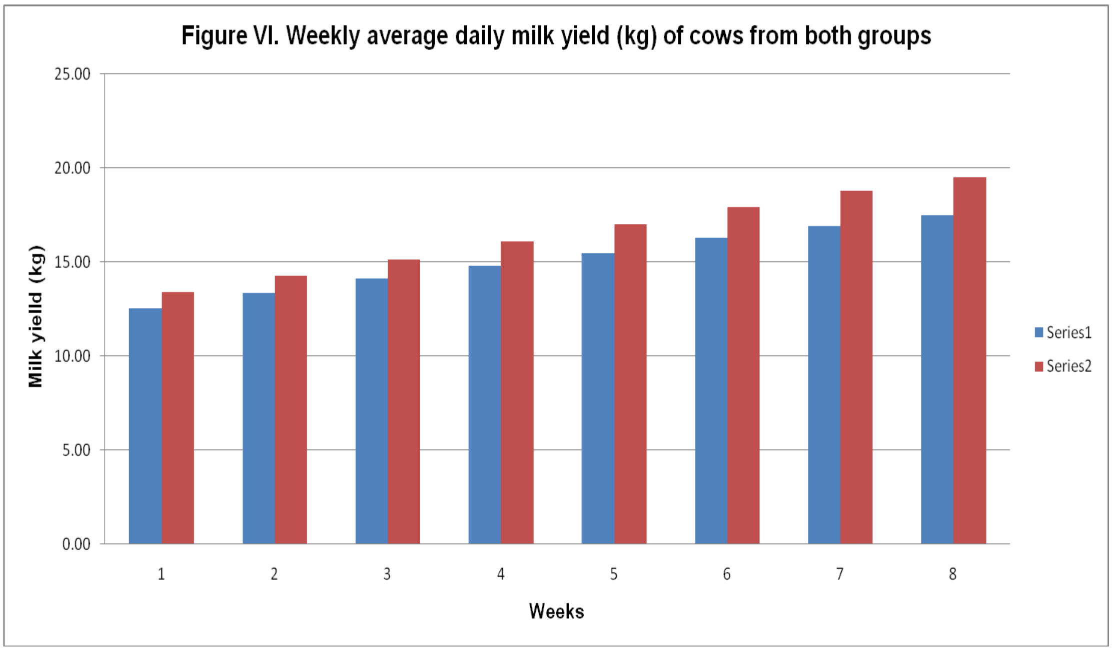


Figure VI. Weekly average daily milk yield (kg) of cows from both groups
25.00
20.00
15.00
10.00
5.00
0.00
Milk yielld (kg)
1
2
3
4
5
6
7
8
Weeks
Series1
Series2

4.3. Fat corrected milk yield (FCM):

The weekly average daily FCM yield of both experimental groups is presented in Table 6 and the same is depicted graphically in Figure VII. It was observed from the data that the daily average FCM yield ranged from 11.78 kg to 17.90 kg. The average daily FCM yield of cows from control and treatment groups was 13.61 and 15.48 kg, respectively. The FCM yield of treatment group was higher than control group.

The average FCM yield data were subjected to statistical analysis by using paired 't' test. The result indicated that the average FCM yield of cows from treatment group was significantly ($P<0.01$) higher than control. Thus, it is seen that the cows receiving by pass fat produced significantly more FCM than the control group, indicating the beneficial effect of bypass fat. The significantly higher FCM yield may be attributed due to higher energy intake, more efficient use of fat by mammary gland and enhancement of tissue mobilization before peak production.

The findings of the present study are in accordance with Yadav *et al.* (2015) who reported higher FCM yield for treatment group (15.65±0.18 kg) supplemented with prilled bypass fat than control group (13.06±0.21 kg) in crossbred cows. Sontakke *et al.* (2014) observed higher FCM yield in treatment group supplemented with bypass fat @ 3% in concentrate mixture than control. Patel *et al*. (2013) reported higher FCM yield in treatment group (18.55 kg) supplemented with bypass fat @ 10 gm/kg of milk yield as compared to control (15.30 kg) in crossbred cows. Sirohi *et al*. (2010) reported higher FCM yield in treatment group (14.89 kg) as compared to control (12.01 kg) in lactating crossbreed cows supplemented with bypass fat @ 300 gm/day/animal**.** Similar results were reported by Cannale *et al.* (1990), Garg and Mehta (1998), Mishra *et al.* (2004), Raikar and Thakur (2007), Tyagi and Thakur (2007) and Naik *et al.* (2009) in crossbred cows.

Ramteke *et al.* (2014) reported higher FCM yield in treatment group (7.66±0.03 kg) than control (7.18 ±0.04 kg) which was significantly ($P<0.01$) higher in group supplemented with bypass fat in buffaloes. Ranjan *et al*. (2013) found that the FCM yield was higher in bypass fat supplemented group as compared to control. Similar results were observed by Bhosale (2009), Parnerkar *et al.* (2010) and Desai *et al.* (2012) in lactating buffaloes.

Contrary to the present study, Kent and Arambel (1988) and Schauf and Clark (1989) reported statistically non-significant effect of bypass fat supplementation on FCM yield in crossbred cows.

Table 6. Weekly average daily FCM yield (kg) of cows from both groups

Week	Control	Treatment
1	11.78	12.72
2	12.38	13.48
3	12.98	14.36
4	13.41	15.11
5	13.89	16.05
6	14.36	16.85
7	14.95	17.41
8	15.11	17.90
Average ± SE	**13.61±0.422**	**15.48±0.666**

Significant t_{14} $P<0.01$

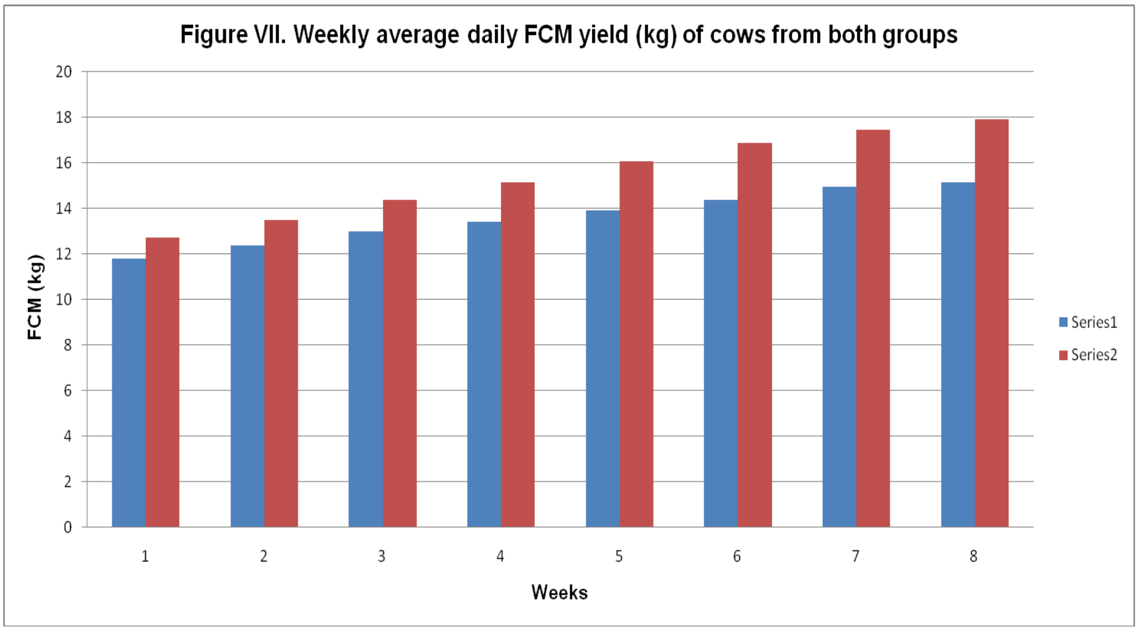


Figure VII. Weekly average daily FCM yield (kg) of cows from both groups
FCM (kg)
0
2
4
6
8
10
12
14
16
18
20
1
2
3
4
5
6
7
8
Weeks
Series1
Series2

4.4 .TDN intake:

The weekly average daily TDN intake of both groups during prepartum and postpartum is presented in Table 7 and 8, respectively. It was observed from the data that, the daily average TDN intake during prepartum and postpartum stage ranged from 4.76 kg to 6.10 kg and 5.39 to 8.21 kg, respectively. The average daily TDN intake of prepartum cows from control and treatment groups was 5.58 kg and 5.79 kg, while that of postpartum cows was 6.74 and 7.11 kg, respectively. The average daily TDN intake of the cows from treatment group was 3.76 % and 5.48 % higher than control group during prepartum and postpartum stage respectively.

The average daily TDN intake data were subjected to statistical analysis by using paired 't' test. The result indicated that the average daily TDN intake of cows from treatment group supplemented with by-pass fat was significantly ($P<0.01$) higher than control. This may be due to increase in digestibility of the nutrients in bypass fat fed group.

These results correlate with the findings of Patel *et al.* (2013) who reported higher TDN intake in treatment group supplemented with bypass fat than in control group, in crossbred cows. Similar results were reported by Sirohi *et al.* (2010) with higher TDN intake in lactating crossbreed cows supplemented with bypass fat @ 300 gm/day/animal.

Ramteke *et al.* (2014) reported statistically higher TDN intake in treatment group supplemented with bypass fat than control, during prepartum and postpartum stage in buffaloes. Shelke *et al.* (2011b) reported higher TDN intake in treatment group supplemented with bypass fat in lactating buffaloes.

However, Purshothaman *et al.* (2008) observed non-significant difference in TDN intake in crossbred cows supplemented with bypass fat. Similarly Ranjan *et al*. (2013) reported non-significant difference for average TDN intake in buffaloes.

Table 7. Weekly average daily TDN intake (kg) of prepartum cows from both groups

Week	Control	Treatment
1	5.88	6.10
2	5.84	6.03
3	5.76	5.98
4	5.66	5.86
5	4.76	4.98
Average ± SE	**5.58±0.208**	**5.79±0.206**

Significant t_8 $P<0.01$

Table 8. Weekly average daily TDN intake (kg) of postpartum cows from both groups

Week	Control	Treatment
1	5.39	5.70
2	5.77	6.17
3	6.19	6.65
4	6.56	7.07
5	7.02	7.39
6	7.18	7.75
7	7.73	7.93
8	8.12	8.21
Average ± SE	**6.74±0.334**	**7.11±0.312**

Significant t_{14} $P<0.01$

4.5. DCP intake:

The weekly average daily DCP intake of both groups during prepartum and postpartum is presented in Table 9 and 10, respectively. It was observed from the data that, the daily average DCP intake during prepartum and postpartum stage ranged from 0.72 kg to 0.91 kg and 0.82 to 1.24 kg, respectively. The average daily DCP intake of prepartum cows from control and treatments group was 0.85 and 0.86, while that of postpartum cows was 1.03 and 1.06, respectively. Further, it is seen that average daily DCP intake of the cows from treatment group was 1.18 % and 2.91 % higher than control in prepartum and postpartum phase respectively.

The average daily DCP intake data were subjected to statistical analysis by using paired 't' test. The result revealed that the average daily DCP intake of cows from treatment group supplemented with bypass fat during prepartum and postpartum phase was significantly higher (P<0.01) and (P<0.05) level of significance respectively.

The findings of the present study are in agreement with Sirohi *et al.* (2010) with higher DCP intake in lactating crossbreed cows. Shelke *et al.* (2011[a]) observed higher (P<0.05) average DCP intake in the group fed with rumen protected fat @ 2.5% of DMI as compared to those in control in buffaloes.

However, the finding of present study are not in accordance with, Patel *et al.* (2013) who reported non-significant difference for DCP intake in experimental cows. Ranjan *et al.* (2013) reported almost similar DCP intake between experimental buffaloes.

Table 9. Weekly average daily DCP intake (kg) of prepartum cows from both groups

Week	Control	Treatment
1	0.90	0.91
2	0.89	0.90
3	0.88	0.89
4	0.86	0.88
5	0.72	0.74
Average ± SE	**0.85±0.03**	**0.86±0.03**

Significant t_8 P<0.01

Table 10. Weekly average daily DCP intake (kg) of postpartum cows from both groups

Week	Control	Treatment
1	0.82	0.85
2	0.88	0.92
3	0.94	0.99
4	1.00	1.06
5	1.07	1.1
6	1.09	1.16
7	1.18	1.18
8	1.24	1.23
Average ± SE	**1.03±0.051**	**1.06±0.047**

Significant t_{14} $P<0.05$

4.6. Feed efficiency:

The efficiency of feed utilization by cows of both the groups was calculated in terms of DM, TDN and DCP required per kg of FCM yield produced. The data pertaining to DM, TDN and DCP intake per kg FCM yield are presented in table 11, 12, 13, respectively and the same is depicted graphically in Figure VIII.

4.6.1. Dry matter intake (kg)/ kg FCM yield:

The weekly average daily DMI (kg) required per kg FCM yield for cows from both experimental groups is presented in Table 11. It is seen from the data that, the average DM required per kg FCM yield production for cows from control and treatment group was 0.74 kg and 0.67 kg, respectively. The treatment group was more efficient over control group.

The average daily DM intake per kg FCM yield data were subjected to statistical analysis by using paired 't' test. The result indicated that treatment group had significant ($P<0.01$) effect on the efficiency of feed utilization when considered in terms of DM required per kg FCM yield.

The findings of the present study are in agreement with Tyagi and Thakur (2007) who reported better feed efficiency in terms of DM intake per kg FCM yield in bypass fat supplemented group in crossbred cows.

Ranjan *et al.* (2013) reported better efficiency of DM intake per kg FCM yield in bypass fat supplemented animals. Desai *et al.* (2012) and Bhosale (2009) reported improved feed efficiency in bypass supplemented buffaloes.

However, Sirohi *et al*. (2010) reported non-significant difference in dry matter intake per kg FCM in lactating crossbred cows.

Table 11. Weekly average total daily dry matter intake (kg)/kg FCM yield of cows from both groups

Week	Control	Treatment
1	0.69	0.65
2	0.70	0.66
3	0.72	0.67
4	0.73	0.68
5	0.76	0.67
6	0.75	0.67
7	0.78	0.66
8	0.81	0.67
Average ± SE	**0.74±0.014**	**0.67±0.003**

Significant t_{14} $P<0.01$

4.6.2. TDN intake (kg)/ kg FCM yield:

The week wise efficiency of feed utilization in terms of TDN required per kg FCM for cows from different groups is presented in Table 12. It is seen that the cows from control and treatment group required 0.49 and 0.46 kg TDN per kg FCM produced, respectively. Thus, the cows from group II receiving by-pass fat, required 0.03 kg less of TDN for production of each kg of FCM, indicating better efficiency in bypass supplemented group.

The data were subjected to statistical analysis by using paired ‘t’ test. The result indicated that the supplementation of bypass fat had significant ($P<0.01$) effect on the TDN required per kg of FCM produced by cows. The significant effect was seen in improving the efficiency of feed utilization in terms of TDN required per kg FCM yield in treatment group as compared to control group.

These results correlate with the findings of Sirohi *et al*. (2010) who reported significant effect of bypass fat on TDN intake per kg FCM yield in lactating cows. Tyagi and Thakur (2007) reported better feed efficiency in terms of TDN intake per kg FCM yield in bypass fat supplemented group in crossbred cows.

Similar results were also reported by Bhosale (2009) in lactating buffaloes.

Table 12. Weekly average total TDN intake (kg)/kg FCM yield of cows from both groups

Week	Control	Treatment
1	0.46	0.45
2	0.47	0.46
3	0.48	0.46
4	0.49	0.47
5	0.51	0.46
6	0.50	0.46
7	0.52	0.46
8	0.54	0.46
Average ± SE	**0.49±0.009**	**0.46±0.002**

Significant t_{14} $P<0.01$

4.6.3. DCP intake (kg)/ kg FCM yield:

The week wise average DCP required per kg FCM produced by both the groups is presented in Table 13. It is noticed from the table that average efficiency was 0.075 and 0.069 kg for control and treatment group, respectively, in terms of DCP required per kg FCM. Thus it is indicated that for the by-pass fat supplemented group the efficiency of DCP utilization for FCM was higher than control group, receiving no by-pass fat supplementation.

The above data were subjected to statistical analysis by using paired 't' test and result revealed that bypass supplementation had significant ($P<0.01$) effect on DCP utilization. Thus DCP required per kg FCM revealed same trend as that observed for TDN required per kg FCM.

These results correlate with the findings of Sirohi *et al*. (2010) who reported significant effect of bypass fat on DCP intake per kg FCM in lactating crossbred cows. The findings of the present study are in agreement with Tyagi and Thakur (2007) who reported better efficiency of DCP intake per kg FCM yield in bypass fat supplemented group in crossbred cows.

Bhosale *et al*. (2009) reported similar results in buffaloes supplemented with bypass fat.

Table 13. Weekly average total DCP intake (kg)/kg FCM yield of cows from both groups

Week	Control	Treatment
1	0.070	0.067
2	0.071	0.068
3	0.073	0.069
4	0.075	0.070
5	0.077	0.069
6	0.076	0.069
7	0.079	0.068
8	0.082	0.069
Average ± SE	**0.075±0.001**	**0.069±0.000**

Significant t_{14} $P<0.01$

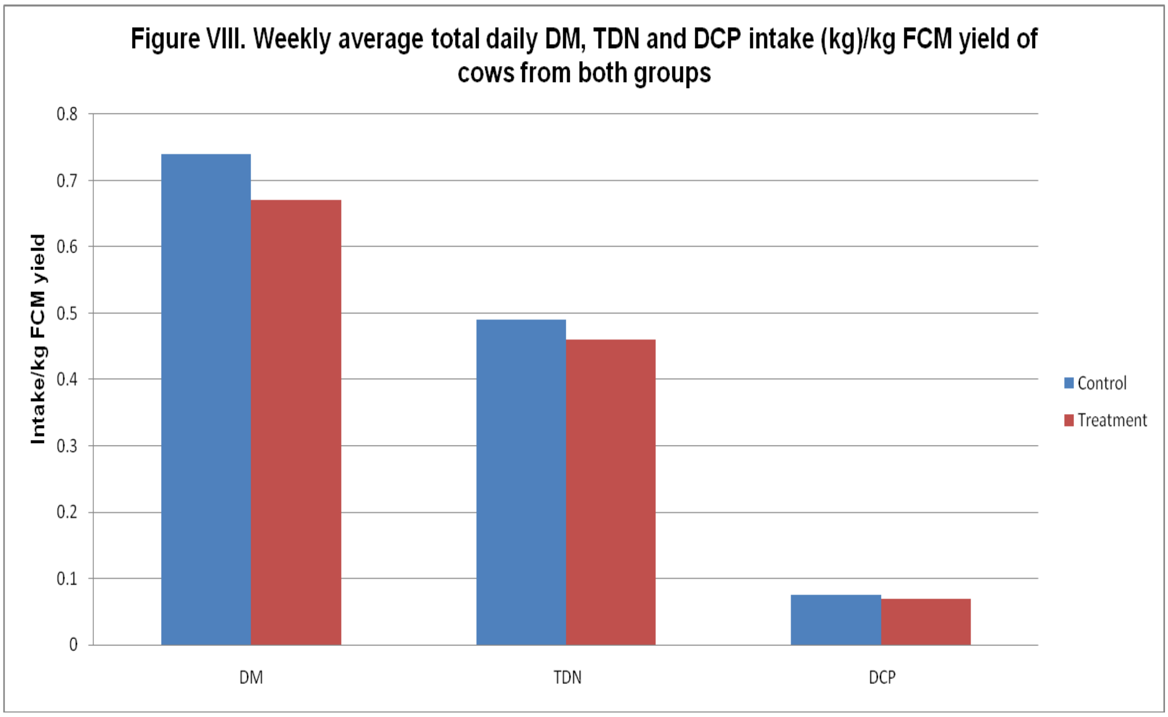


Figure VIII. Weekly average total daily DM, TDN and DCP intake (kg)/kg FCM yield of cows from both groups
Intake/kg FCM yield
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DM
TDN
DCP
Control
Treatment

4.7. Milk composition:

The weekly samples from individual cows from both groups were collected for estimation of protein, fat, SNF, total solids and specific gravity.

4.7.1 Milk protein:

The weekly average milk protein percentage from both groups is presented in Table 14 and the same is depicted graphically in Figure IX. The average milk protein percentage for control and treatments group was 3.35 and 3.36, respectively. It is observed that the milk protein content was marginally higher in treatment group as compared to control group.

The data obtained for milk protein were subjected to statistical analysis by using paired ‘t’ test. From the statistical analysis of data, it is revealed that the milk protein content of experimental group was statistically non- significant. The reason of non-significant effect of bypass fat supplementation on milk protein may be improper ratio of protein to fat in the diet or the supply of amino acids through DMI may not be proper.

This is corroborate with the findings of Yadav *et al.* (2015) who reported non-significant difference in milk protein percentage among control (3.67%) and bypass fat supplemented (3.69%) crossbred cows. Sontakke *et al.* (2014) observed statistically non-significant milk protein percentage among control and treatment group. Rajesh *et al.* (2014) reported that there was no influence on milk protein percentage in crossbred cows supplemented with bypass fat. Wadhwa *et al.* (2012) observed statistically similar protein percentage in the experimental crossbred cows. Similar results were reported by Tyagi and Thakur (2007), Lounglawan *et al.* (2008), Purshothaman *et al.* (2008), Naik *et al.* (2009), Sirohi *et al.* (2010) and Zhang *et al.* (2011) in crossbred cows. Shelke *et al.* (2012), reported similar results in lactating buffaloes.

However, Han *et al.* (2011) and Moallem *et al*. (2007) who reported higher milk protein percentage in bypass fat supplemented crossbred cows. Ranjan *et al.* (2013) and Dhulipalla *et al.* (2013) reported higher milk protein percentage in lactating buffaloes supplemented with bypass fat.

Table 14. Weekly average milk protein (%) of cows from both groups

Week	Control	Treatment
1	3.42	3.41
2	3.41	3.40
3	3.39	3.38
4	3.36	3.37
5	3.34	3.35
6	3.32	3.35
7	3.30	3.32
8	3.27	3.29
Average ± SE	**3.35±0.019**	**3.36±0.014**

NS- Non significant

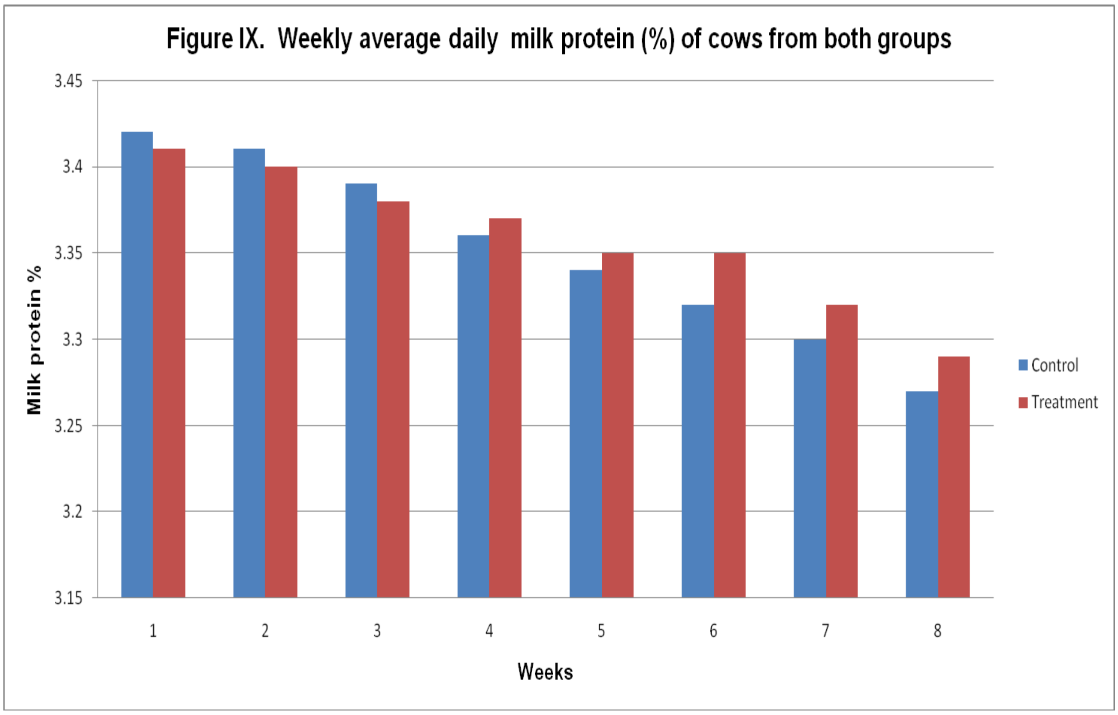


Figure IX. Weekly average daily milk protein (%) of cows from both groups
3.45
3.4
3.35
3.3
3.25
3.2
3.15
Milk protein %
1
2
3
4
5
6
7
8
Weeks
Control
Treatment

4.7.2. Milk fat:

The weekly average fat percentage of milk from both the groups is presented in Table 15 and the same is depicted graphically in Figure X. The average milk fat from both the goups ranged from 3.10 % to 3.67 %. It is noticed from the table that average milk fat percentage for groups I and II was 3.35 and 3.60, respectively. Thus, the average milk fat for treatment group was higher than control group.

The data obtained for milk fat percentage were subjected to statistical analysis by using paired ‘t’ test. The data revealed that the milk fat in treatment group was significantly (P<0.01) higher than the control. This effect on milk fat percentage may be due to more availability of fatty acids for absorption in intestine due to protection of fat and these fatty acids are directly incorporated in milk fat after absorption from intestine, leading to increase in milk fat. The other reason for increase in the milk fat percentage may be due to higher dietary fat from feed, which enhanced supply of fatty acids to mammary gland.

Simliar results were reported by Yadav *et al.* (2015) who reported higher milk fat % in treatment group (4.71±0.18) than control group (4.22±0.14) in crossbred cows supplemented with bypass fat @ 150 gm/day/animal. Rajesh *et al.* (2014) found increase in fat percentage by 9% in treatment group when fed prilled bypass fat @ 75 gm/animal/day in crossbred cows. Ansar *et al*. (2014) reported higher milk fat % in bypass fat supplemented crossbred cows. Patel *et al.* (2013) observed higher milk fat % in treatment group (0.77 kg/day) as compared to control (0.60 kg/day). Bhanderi *et al*. (2011) reported higher milk fat % in treatment (4.14 %) as compared to control (3.60 %). Similar results in crossbred cows were reported by Mishra *et al.* (2004), Vidhate *et al.* (2006), Sirohi *et al.* (2010), Han *et al.* (2011) and Zhang *et al.* (2011).

Ramteke *et al.* (2014) reported higher milk fat percentage in buffaloes supplemented with bypass fat. Dhulipalla *et al.* (2013) reported higher fat percentage 5.78% in treatment group as compared to 5.59% in control group, in buffaloes supplemented with bypass fat @100 gm/day/animal. Shelke *et al*. (2012) and Desai *et al*. (2012) reported higher milk fat % in buffaloes supplemented with bypass fat. Bhosale (2009) observed higher fat % in lactating buffaloes supplemented with bypass fat @ 100 gm/day/animal.

However, no significant effect of bypass fat supplementation was observed by Wadhwa *et al.* (2012) on milk fat percentage in crossbred cows. Naik *et al*. (2009) reported statistically non-significant effect of supplementation of bypass fat @ 200 gm/day/animal on milk fat % in crossbred cows. Similar results were reported by Tyagi and Thakur (2007), Moallem *et al.* (2007), Purshothaman *et al.* (2008) and Lounglawan *et al.* (2008) in crossbred cows. Ranjan *et al.* (2013) reported non-significant effect of supplementation of bypass fat on milk fat % in lactating buffaloes.

Table 15. Weekly average daily milk fat (%) of cows from both groups

Week	Control	Treatment
1	3.61	3.67
2	3.51	3.64
3	3.47	3.66
4	3.38	3.60
5	3.32	3.63
6	3.21	3.61
7	3.23	3.52
8	3.10	3.46
Average ± SE	**3.35±0.061**	**3.60±0.026**

Significant t_{14} $P<0.01$

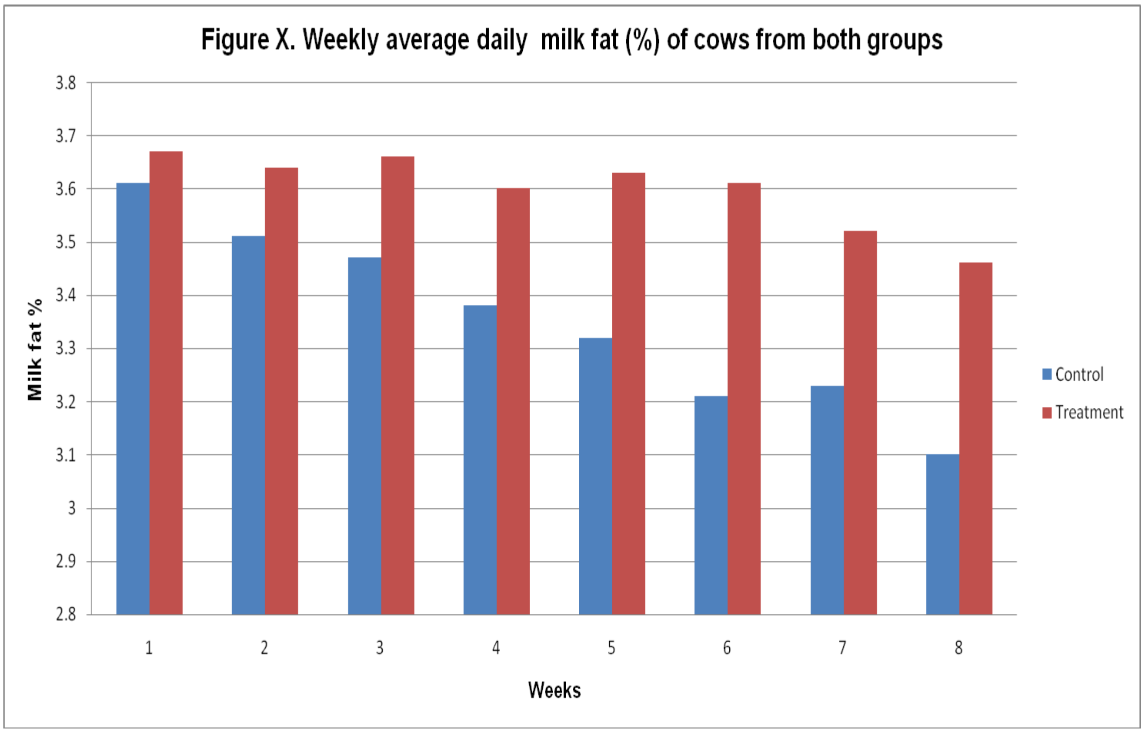


Figure X. Weekly average daily milk fat (%) of cows from both groups
Milk fat %
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
1
2
3
4
5
6
7
8
Weeks
Control
Treatment

4.7.3. Milk total solids:

The weekly average total solids percentage of milk from both the groups is presented in Table 16 and the same is depicted graphically in Figure XI. From the table it is observed that the average total solid for control and treatment group was 11.65 and 11.92 %, respectively.

The data obtained for total solids percentage were subjected to statistical analysis by using paired 't' test. The result indicated that use of bypass fat supplement significantly ($P<0.01$) increased the total solids percentage of milk in treatment group.

This is corroborate with the findings of Han *et al.* (2011) who observed higher milk total solid percentage by 4.08% in bypass supplemented group @ 300 gm/day/animal than control group in crossbred animals. Bhanderi *et al.* (2011) reported higher total solid percentage in treatment group (13.16) as compared to (12.54) in control group. Similar results were reported by Sirohi *et al.* (2010) and Mishra *et al.* (2004) in crossbred cows.

Dhulipalla (2013) reported significant effect of supplementation of bypass fat on total solid percentage among treatment and control group as 15.9% and 16.3%, respectively, in Murrah buffaloes. Similarly Bhosale *et al.* (2009) reported higher milk total solid percentage in lactating buffaloes supplemented with bypass @ 100 gm/animal/day.

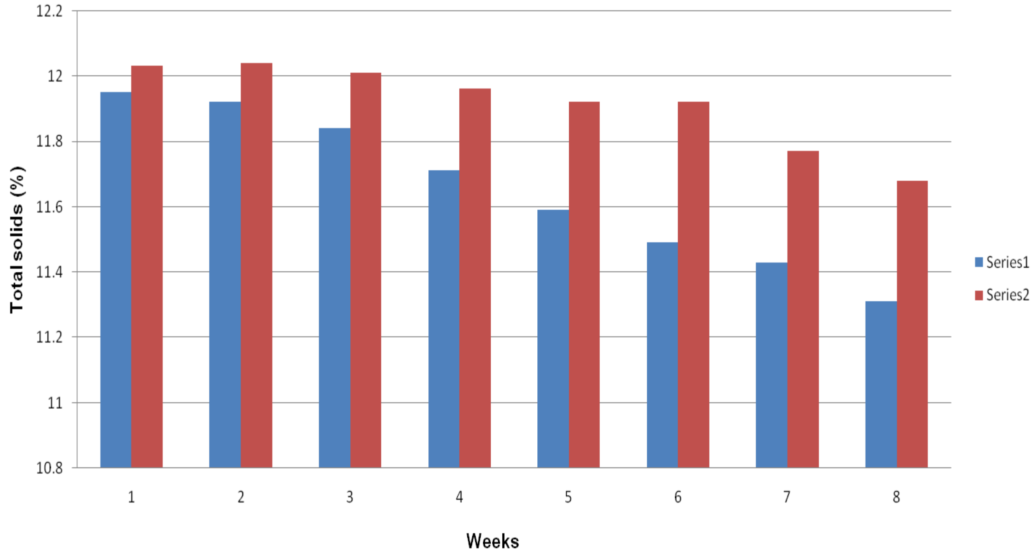
However, Ramteke *et al.* (2014) reported no significant difference between control and treatment group in buffaloes. Ranjan *et al.* (2013) found similar results in bypass fat supplemented animals.

Table 16. Weekly average milk total solids (%) of cows from both groups

Week	Control	Treatment
1	11.95	12.03
2	11.92	12.04
3	11.84	12.01
4	11.71	11.96
5	11.59	11.92
6	11.49	11.92
7	11.43	11.77
8	11.31	11.68
Average ± SE	**11.65±0.084**	**11.92±0.045**

Significant t_{14} $P<0.01$

Figure XI. Weekly average daily milk total solid (%) of cows from both groups



4.7.4. Milk solid not fat content (SNF):

The weekly average solid not fats (SNF) percentage of milk from both groups is presented in Table 17 and the same is depicted graphically in Figure XII. The average SNF percentage for control and treatments group was 8.30 and 8.32 respectively.

The data obtained for milk SNF percentage were subjected to statistical analysis by using paired t test. From the statistical analysis of data, it is revealed that the difference in the content of milk SNF in experimental groups was non-significant.

Similar results were reported by Rajesh *et al.* (2014) who found no influence on milk SNF percentage between treatment and control group. Sontakke *et al.* (2014) reported non-significant difference between control and treatment group. Similar results were reported by Tyagi and Thakur (2007), Lounglawan *et al.* (2008), Purshothaman *et al.* (2008) , Naik *et al.* (2009), Sirohi *et al.* (2010) and Wadhwa *et al.* (2012) in crossbred cows.

Ranjan *et al.* (2013) and Shelke *et al.* (2012) reported non-significant effect of bypass fat on milk SNF percentage in buffaloes.

Contrary to present findings, Yadav *et al.* (2015) found higher percentage of average milk SNF in treatment group (10.19±0.19) as compared to control group (9.89±0.19). Similarly Patel *et al.* (2013) and Han *et al.* (2011) reported higher SNF % in bypass supplemented crossbred cows. Ramteke *et al.* (2014) reported lower SNF percent of milk in treatment group (8.91±0.04) than control group (9.12±0.05), respectively in buffaloes.

Table 17. Weekly average milk SNF (%) of cows from both groups

Week	Control	Treatment
1	8.34	8.36
2	8.41	8.38
3	8.37	8.37
4	8.33	8.36
5	8.27	8.29
6	8.29	8.32
7	8.20	8.25
8	8.21	8.22
Average ± SE	**8.30±0.026**	**8.32±0.021**

NS- Non-significant

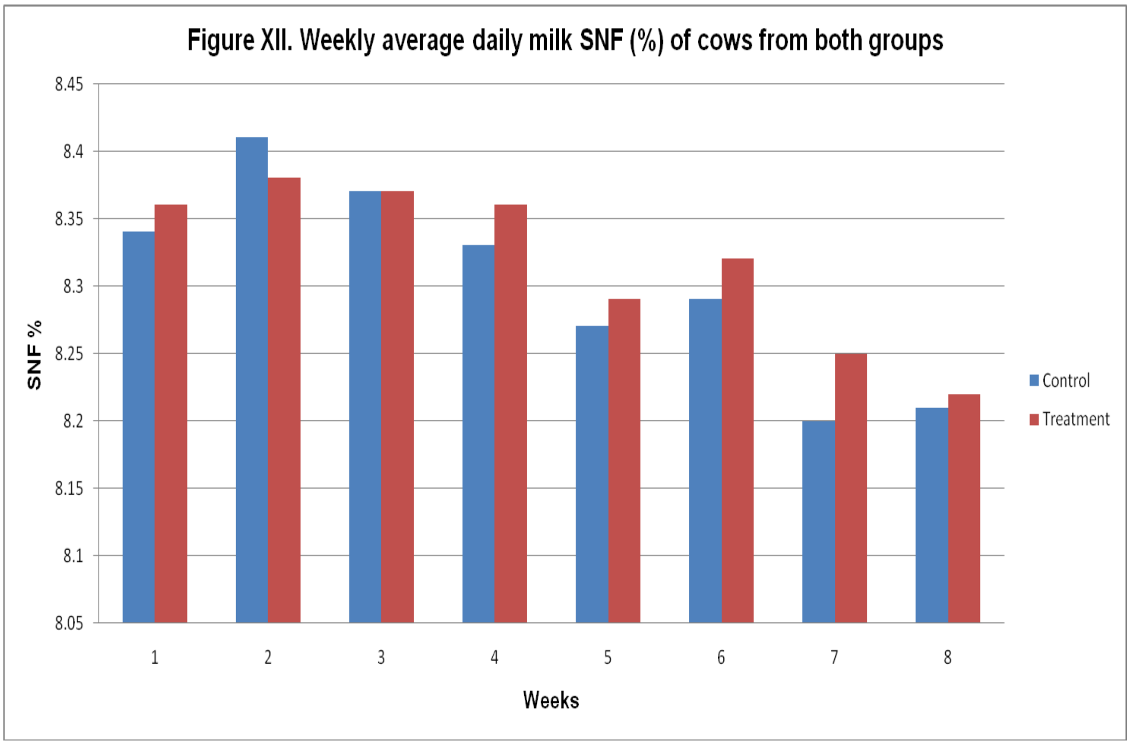


Figure XII. Weekly average daily milk SNF (%) of cows from both groups
SNF %
8.45
8.4
8.35
8.3
8.25
8.2
8.15
8.1
8.05
1
2
3
4
5
6
7
8
Weeks
Control
Treatment

4.7.5. Milk specific gravity:

The data pertaining to average specific gravity of milk from both the groups are presented in Table 18. The average specific gravity of milk for control and treatment group was 1.028 and 1.029, respectively. This indicated marginal effect of by-pass fat on average specific gravity of the milk, which is due to higher total solids content in treatment group as compared to that in control group.

The data of average specific gravity of milk were subjected to statistical analysis. It is observed from the statistical analysis that the treatment group had significant ($P<0.01$) effect on specific gravity of milk. This indicates that by-pass fat supplementation significantly increased specific gravity of the milk.

Similar results were reported by Bhosale (2009) after supplementing bypass fat in lactating buffaloes.

Table 18. Fortnightly average milk specific gravity of cows from both groups

Week	Control	Treatment
1	1.028	1.030
2	1.028	1.029
3	1.029	1.030
4	1.028	1.030
5	1.028	1.030
6	1.028	1.029
7	1.029	1.029
8	1.028	1.028
Average ± SE	**1.028±0.000**	**1.029±0.000**

Significant t_{14} $P<0.01$

4.8. Body condition score (BCS):

The BCS of animals were recorded at fortnightly interval. Scoring system of 1 to 5 point scale using 0.25 increments for Holstein Friesian cows as per Ferguson *et al.* (1994) and confirmed by Elanco (1997) to record BCS of each individual cows.

The data pertaining to average body condition score during prepartum and postpartum stage is presented in Table 19 and 20 and the same is depicted graphically in Figure XIII. The table revealed that the body condition score was 3.64 and 3.66 during prepartum and 3.10 and 3.27 during postpartum stage for control and treatment group, respectively. The higher BCS during postpartum phage in treatment group may be due to supplementation of bypass fat which helped to reduce the mobilization of body reserve fat during peak milk production.

The data of average body condition score were subjected to statistical analysis using paired “t” test. It is observed from the statistical analysis that the body condition score during prepartum stage was statistically non-significant while statistically significant ($P<0.05$) during postpartum stage.

Similarly, Yadav *et al.* (2015) reported improved body condition score in treatment group as compared to control group in crossbred cows. Rajesh *et al.* (2014) reported higher body condition score in treatment group supplemented with prilled bypass fat @75 gm/day/animal in crossbred cows. Naik *et al*. (2013) reported improvement in postpartum body weight and body condition score in dairy animals.

Table 19. Fortnightly average body condition score (BCS) of prepartum cows from both the groups

Week	Control	Treatment
1	3.71	3.67
2	3.67	3.67
3	3.54	3.63
Average ± SE	**3.64±0.051**	**3.66±0.013**

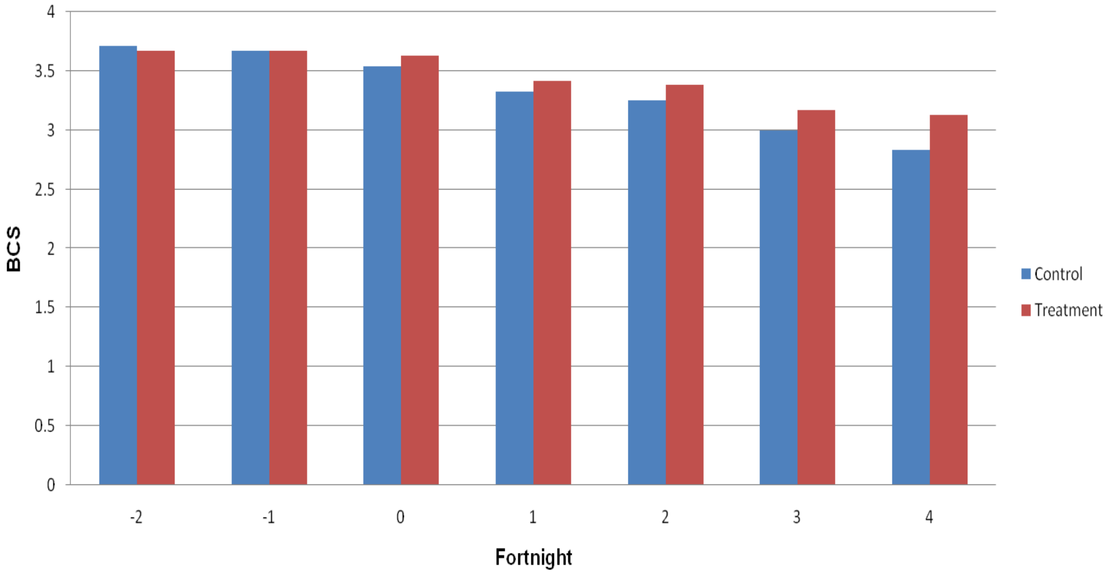
NS- Non-significant.

Table 20. Fortnightly average body condition score (BCS) of postpartum cows from both the groups

Week	Control	Treatment
1	3.33	3.42
2	3.25	3.38
3	3.00	3.17
4	2.83	3.13
Average ± SE	**3.10±0.115**	**3.27±0.073**

Significant t_6 $P<0.05$

Figure XIII. Fortnightly average body condition score (BCS) during prepartum and postpartum stage of cows from both groups



4.9. Digestion trial:

During the last week of study a digestibility trial of seven days duration was conducted by total collection method on four animals from each group and the digestibility coefficients for different nutrients were calculated. The digestibility coefficients for dry matter, organic matter, crude protein, ether extract, crude fibre and NFE for both the groups are presented in Table 21.

It is evident from the table that average digestibility coefficients for dry matter were 70.35 % and 72.45% for control and treatment group, respectively. Thus, the digestibility of DM in group II was 2.99% higher than that in group I.

The average digestibility coefficients for organic matter were 71.35 % and 73.15 % for groups I and II, respectively, indicating the same trend as that of DM digestibility. The digestibility of organic matter in bypass fat supplemented group was 2.52 % higher than control group.

It is seen from the table that average digestibility coefficients for crude protein were 72.11 and 75.42 % for groups I and II, respectively. Thus, the digestibility of crude protein was 4.6 % higher for by pass fat supplemented group than control.

The average digestibility coefficients for crude fibre were 60.23 and 62.55 group I and II, respectively, which again indicated that by pass fat supplemented group had 3.85 % higher digestibility for crude fibre as compared to control group. The results of the present study also revealed that addition of rumen protected fat did not adversely affect fibre digestibility which is generally observed in case of supplementation with oils or free fatty acids.

The average digestibility coefficient for ether extract was higher in treatment group (75.15 %) as compared to control (71.26%). The digestibility for ether extract in bypass fat supplemented group was 5.45 % higher than control. The higher digestibility of ether extract in the bypass fat supplemented group may be due to higher utilization of bypass fat as in bypass fat majority was the true fat.

It is also seen from the table that the average digestibility coefficients for groups I and II for NFE were 69.35 and 71.42 %, respectively. Thus, the digestibility of NFE was higher in bypass fat supplemented group than control group.

It is revealed from Table 20 that average TDN content of ration for groups I and II was 66.65 and 68.95%, respectively. While, the average DCP percentages for corresponding groups were 10.16 and 10.30 %, respectively. This indicated that the TDN and DCP content of ration was 3.45 % and 1.37 % higher in bypass fat supplemented group than control.

Thus, in general, it is seen that in lactating cows, overall digestibility of all the nutrients was higher for group II, i.e. is bypass fat supplemented group than control. This, in turn, was reflected in higher TDN and DCP values for the corresponding ration.

In agreement with present finding, Sirohi *et al.* (2010) reported higher TDN and DCP values for group supplemented with bypass fat.

Table 21. Average percent digestibility coefficients, TDN and DCP contents for both groups

Sr. No.	Nutrient	Control	Treatment
1	**Dry matter**	70.35	72.45
2	**Organic matter**	71.35	73.15
3	**Crude protein**	72.11	75.42
4	**Crude fibre**	60.23	62.55
5	**Ether Extract**	71.26	75.15
6	**Nitrogen Free Extract**	69.35	71.42
7	**TDN**	66.65	68.95
8	**DCP**	10.16	10.30

4.10. Economics:

The profit in dairy animal production depends mainly on input-output relationship. Hence, attempt was made to study economics of dairy production by calculating daily returns per cow from both the groups. The profit was worked out by considering mainly the cost of feeds and fodders and the amount realized on the sale of the milk. The input-output relationship for both the groups is presented in Table 22.

It is seen from the table that cost per kg concentrate was₹.16.80 for both the groups. The cost of feeding bypass fat supplement was₹.12.60 for Group II. The total cost of feeding per day per cow was₹.155.50 and ₹171.06 for groups I and II, respectively. Thus, the feeding cost was higher in by pass fat supplement fed group than control group.

The total cost per kg milk production was₹.11.88 and 11.95 for treatment and control group, respectively. Thus, indicating higher total cost per kg milk produced for the control group than group with bypass fat supplement. When the cost was considered on the basis of daily fat corrected milk production, it was again higher for control group (₹13.26) than treatment group (₹12.66). This showed 4.52 % decrease in cost of production per kg FCM in bypass fat supplemented group than control group. This indicated the cost effectiveness of bypass fat in treatment group over control group.The milk was sold at farm price of ₹35/kg. The total income earned from sale of milk was ₹528.85 and 577.50 for control and treatment group, respectively. The corresponding values for profit realized per cow were₹348.35 and 381.44 for control and treatment group respectively which was 9.5 % higher in treatment group. Thus, the extra profit of ₹33.09/- was recorded with treatment group receiving bypass fat than that of control group.

Naik *et al.* (2009) reported a net profit of ₹34.50/- per cow per day, during early lactation supplemented with rumen protected fat. A net profit ₹33of.92/ - per buffalo per day was reported by Bhosale (2009). Ranjan *et al*. (2013) observed 71.8% more profit in bypass fat supplemented group than control in buffaloes.

Thus, it is observed that the use of bypass fat supplement was cost effective as compared to cows from control group receiving no bypass fat supplement.

Table 22. Input-Output relationship:

Particulars	Control	Treatment
Intake (kg/day/animal)		
Concentrate	4.44	4.45
Lucern grass	14.12	14.71
Guinea grass	15.42	15.83
Bypass fat	-	0.140
Cost (Rs/kg)		
Concentrate	16.80	16.80
Lucern grass	3	3
Guinea grass	2.5	2.5
Bypass fat	-	90
Total feed cost (Rs/day)/animal		
Concentrate	74.59	74.76
Lucern grass	42.36	44.13
Guinea grass	38.55	39.57
Bypass fat	-	12.60
Total feed cost (₹)	155.50	171.06
Miscellaneous cost* (₹/day)	25	25
Total expenses (Rs/day)	180.50	196.06
Average daily milk production (₹/cow)	15.11	16.50
Total cost of milk production (₹/kg)	11.95	11.88
Average daily FCM Production (₹/cow)	13.61	15.48
Total cost of FCM production (₹/kg)	13.26	12.66
Daily income from milk sale** (₹)	528.85	577.50
Daily profit through sale of milk (₹/ cow)	348.35	381.44
Extra profit over control (₹/cow)	-	33.09

* - Includes labour, vaccination and other overhead costs.

**- Rate of milk was ₹35.00 per kg.

4.11. Overall performance:

The overall performance of cows from both the groups is presented in Table 23. It is seen from the table that values for average DM intake were non-significant between both the experimental groups. The nutrient intake, when considered in terms of TDN and DCP, revealed that the intake in group II receiving bypass fat supplement was significantly higher than group I. It is also seen from the table that absolute and FCM yields were significantly higher in treatment group than the control group.

The efficiency of feed utilization in terms of DM, TDN and DCP intake per kg FCM production was also significantly better for group II than the group I. The table also revealed that the composition of milk in terms of milk fat, total solids percentage and specific gravity was significantly higher in treatment group than control . However the milk protein and SNF were non-significant.

The overall results of the present study indicated that bypass fat supplementation to lactating cows proved beneficial in terms of dry matter intake, increased milk yield, improved milk composition, higher efficiency of feed utilization and overall nutrient digestibility. It also revealed that the use of such supplement is cost effective. Results also indicated that BCS was better in bypass fat supplemented group as the fat mobilization for fulfilling energy required may not be at large extent during early lactation period.

Table 23. Overall performance of cows from both groups

Parameters	Control	Treatment	Result of 't' test
Dry matter intake prepartum (kg)	8.37	8.40	NS
Dry matter intake postpartum (kg)	10.12	10.31	NS
TDN %	66.65	68.95	-
TDN intake prepartum (kg)	5.58	5.79	* *
TDN intake postpartum (kg)	6.74	7.11	* *
DCP %	10.16	10.30	-
DCP intake prepartum (kg)	0.85	0.86	* *
DCP intake postpartum (kg)	1.03	1.06	*
Milk yield (kg)	15.11	16.50	* *
FCM yield (kg)	13.61	15.48	*
DM intake (kg)/ kg FCM yield	0.74	0.67	* *
TDN intake (kg)/ kg FCM yield	0.49	0.46	* *
DCP intake (kg)/ kg FCM yield	0.075	0.069	* *
Milk protein %	3.35	3.36	NS
Milk fat %	3.35	3.60	* *
Milk SNF %	8.30	8.32	NS
Total solid %	11.65	11.92	* *
Specific gravity	1.028	1.029	* *
Body condition score prepartum	3.64	3.66	NS
Body condition score postpartum	3.10	3.27	*

NS – Non-Significant.

∗ -- Significant at 5% level.

∗ ∗ -- Significant at 1% level.

5. SUMMARY AND CONCLUSIONS

The present study was conducted on crossbred cows at Manoj Dairy Farm located at Rahuri, Ahemadnagar and in the Department of Animal Nutrition, Bombay Veterinary College, Parel, Mumbai-12. The effect of bypass fat supplementation @ 30 gm/100 kg body weight on prepartum and postpartum phage was experimented. During the experimental period milk production and its composition was studied. Digestibility of feed and feed efficiency was also studied along with body condition score. The performance of cows on this supplement was compared with cows fed on concentrate mixture without bypass fat supplement.

For this trial, twelve crossbreed Holstein Friesian cows were selected. The selected cows were divided into two groups of six each. The animals were selected on the basis of daily milk yield, gestation and lactation number. The average daily milk production was 10-11 kg/day/animal and 3-4 lactation numbers. The average stage of pregnancy of selected cows was around 30-35 days before parturition. The group I served as control and received concentrate mixture as per routine practice of the farm. The group II served as treatment and was fed with same concentrate mixture as used in the farm, supplemented with by-pass fat @ 30 gm/100 kg body weight. The trial lasted for thirteen weeks.

All the animals from both experimental groups received Lucerne and Guinea grass as a source of roughage. The concentrate mixture for animals from both groups was fed after soaking for 4-6 hrs and the treatment group was fed the bypass fat after topdressing with concentrate mixture.

During the trial, week wise daily milk yield and feed intake were recorded. From this data week wise efficiency of feed utilization by both the groups was calculated. Beside this, the milk samples from individual cow were collected at weekly interval for the study of milk composition. The milk samples were analyzed for total solids, fat, solids not fat, protein and specific gravity. During the experimental period the body condition score (BCS) of animals in both the groups was recorded fortnightly.

During the last week of experiment, a digestibility trial of seven days duration with total collection method was carried out. The trial involved four cows from each group. At the end, the economics of milk production was also studied.

The average week wise daily dry matter intake of prepartum cows from groups I and II was 8.37 and 8.40 kg, respectively while that of postpartum cows was 10.12 and 10.31 kg, respectively. The statistical analysis of data revealed that there was non-significant effect of bypass fat on daily dry matter intake of cows from both the groups

The average daily milk production of cows from groups I and II was 15.11 and 16.50 kg, respectively. It was seen that average daily milk production of cows from group II was significantly ($P<0.01$) higher than control group. This indicates that by-pass supplementation significantly increased milk production in cows.

The average FCM yields for groups I and II was 13.61 and 15.48 kg, respectively. The statistical analysis of the data revealed that supplementation of by-pass fat significantly ($P<0.01$) improved the FCM yield, over the control group.

The average week wise daily TDN intake of prepartum cows for Group I and Group II was 5.58 and 5.79 kg, respectively while that of postpartum cows was 6.74 and 7.11 kg. The statistical analysis of data indicated that treatment group had significantly ($P<0.01$) higher on daily TDN intake.

The average week wise daily DCP intake of prepartum cows for Group I and Group II was 0.85 and 0.86 kg, respectively. The statistical analysis of data indicated that treatment group had significant ($P<0.01$) effect on daily DCP intake. The average week wise daily DCP intake of postpartum cows for Group I and Group II was 1.03 and 1.06 kg, respectively. The statistical analysis of data indicated that treatment group had significantly ($P<0.05$) higher daily DCP intake.

The efficiency of feed utilization by the cows from both the groups was calculated in terms of DM, TDN and DCP intake per kg of FCM yield. The average daily dry matter intake per kg FCM produced was 0.74 and 0.67 kg for groups I and II respectively. The TDN and DCP intake per kg FCM yield for the corresponding groups was 0.49 and 0.46 kg and 0.075 and 0.069 kg, respectively. The efficiency of feed utilization in terms of DM, TDN and DCP required per kg FCM produced was significantly ($P<0.01$) higher for group II, receiving bypass fat supplement than group I.

The week wise average milk protein was 3.35 and 3.36 % for groups I and II, respectively. The statistical analysis of the data revealed that there was non-significant effect on milk protein content after supplementation of bypass fat.

The week wise average milk fat was 3.35 and 3.60 % for groups I and II, respectively. The statistical analysis of the data indicated that there was significantly ($P<0.01$) higher milk fat content for treatment group as compared to control.

The week wise average total solids content of milk was 11.65 and 11.92 % for groups I and II, respectively. The statistical analysis of the data revealed that treatment group had significantly ($P\leq0.01$) higher average milk total solids content than control.

The week wise average solids not fat (SNF) percentage was 8.30 and 8.32 % for groups I and II, respectively. The statistical analysis of the data showed that treatment had non-significant effect on milk SNF.

The average week wise milk specific gravity was 1.028 and 1.029 for the control and treatment group, respectively. The average milk specific gravity data revealed that treatment had significant ($P<0.01$) effect on specific gravity.

Body condition score was recorded at fortnight interval. The average BCS for control and treatment group during prepartum phage was 3.64 and 3.66 which was statistically non-significant for both the experimental groups, while during postpartum phage it was significantly ($P<0.05$) higher for treatment group (3.27) than for control (3.10).

The digestibility trial conducted during last week revealed that the digestibility of DM in group II was higher than group I. The respective values for groups I and II were 70.35 and 72.45 %. The average digestibility coefficients for organic matter were 71.35 and 73.15 % for groups I and II, respectively.

The average digestibility coefficients in groups I and II for crude protein and crude fiber were 72.11 and 75.42 and 60.23 and 62.55 %, respectively. The values of the average digestibility coefficients for the corresponding groups for ether extract and nitrogen free extract were 71.26 and 75.15 % and 69.35 and 71.42 %, respectively. The TDN and DCP contents for the control (group I) and treatment (groups II) were 66.65 and 68.95 and 10.16 and 10.30 %, respectively. Thus, it was seen that digestibility coefficient for all the nutrients and content of TDN and DCP were higher for group II receiving bypass fat supplement.

The economics of the study revealed that average daily feed cost of the cows was Rs 155.50 and 171.06 for control and treatment group, respectively. The total cost per kg of milk production was Rs 11.95 and 11.88 for control and treatment group, respectively. The daily profit incurred through sale of milk was Rs 348.35 and 381.44 for control and treatment group, respectively. A net profit per day per cow was Rs 33.09/- higher and that comes 9.5% higher with bypass fat supplemented group. Thus, the results indicated that supplementation of bypass fat in treatment group was cost effective than control group.

Thus, from the overall results of the present study it is concluded that bypass fat supplementation @ 30 gm/100 kg body weight per day is beneficial in improving milk production, milk composition, nutrient intake, feed efficiency and digestibility of nutrients. Such supplementation is also cost effective. Thus, it can be inferred that for improved production and better margin of profit use of bypass fat supplement is beneficial.

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APPENDIX

Appendix 1. Details of experimental cows used in both groups.

Group- I (Control)				
Sr.No	**Name of cow**	**Lactation Number**	**Average milk yield (kg)**	**Gestation stage (days)**
1	**C1**	3	11	35
2	**C2**	3	10	31
3	**C3**	4	11	33
4	**C4**	4	10.5	32
5	**C5**	4	11	34
6	**C6**	3	11	30
Average		**3.5**	**10.75**	**32.5**

Group- II (Treatment)				
Sr.No	**Name of cow**	**Lactation Number**	**Average milk yield (kg)**	**Gestation stage (days)**
1	**T1**	3	10	30
2	**T2**	4	11	33
3	**T3**	4	10.5	32
4	**T4**	4	11	34
5	**T5**	3	10.5	35
6	**T6**	3	11	31
Average		**3.5**	**10.67**	**32.5**

Appendix 2. Weekly average daily dry matter intake (kg) of prepartum cows from both groups.

Group- I (Control)						
Weeks						
Cows	**1**	**2**	**3**	**4**	**5**	**Average**
C1	8.89	8.75	8.61	8.34	7.35	**8.39**
C2	8.71	8.32	8.39	8.27	7.12	**8.16**
C3	9.65	9.72	9.58	9.34	8.41	**9.34**
C4	7.80	7.95	7.75	7.65	5.53	**7.34**
C5	8.89	8.97	8.80	8.74	7.16	**8.51**
C6	8.99	8.86	8.74	8.62	7.24	**8.49**
Average	**8.82**	**8.76**	**8.65**	**8.49**	**7.14**	**8.37**

Group- II (Treatment)						
Weeks						
Cows	**1**	**2**	**3**	**4**	**5**	**Average**
T1	8.80	8.68	8.63	8.45	7.31	**8.37**
T2	8.13	8.05	8.05	7.95	6.45	**7.73**
T3	8.84	8.88	8.72	8.65	7.21	**8.46**
T4	8.61	8.51	8.58	8.41	8.02	**8.43**
T5	9.49	9.38	9.12	8.85	7.22	**8.81**
T6	9.20	9.00	8.91	8.71	7.12	**8.59**
Average	**8.85**	**8.75**	**8.67**	**8.50**	**7.22**	**8.40**

Appendix 3. Weekly average daily dry matter intake (kg) of postpartum cows from both groups.

Group- I (Control)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	8.01	8.46	9.12	8.87	9.54	10.12	10.79	11.16	**9.51**
C2	7.85	8.57	8.96	9.74	10.65	11.44	12.05	12.46	**10.22**
C3	8.45	8.96	9.78	10.98	10.86	11.61	12.43	13.27	**10.79**
C4	6.55	6.75	7.52	7.86	9.47	8.50	10.51	11.40	**8.57**
C5	8.95	9.83	10.44	10.83	11.91	12.51	12.86	13.12	**11.31**
C6	8.64	9.36	9.94	10.78	10.81	10.46	10.96	11.68	**10.33**
Average	**8.08**	**8.66**	**9.29**	**9.84**	**10.54**	**10.77**	**11.60**	**12.18**	**10.12**

Group- II (Treatment)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	8.78	9.43	9.79	10.38	10.75	11.37	11.72	12.37	**10.57**
T2	7.43	8.12	8.95	9.50	9.45	9.84	10.38	10.81	**9.31**
T3	7.92	8.54	8.88	9.45	9.89	10.47	10.33	10.64	**9.52**
T4	8.81	9.42	10.48	11.90	12.58	12.83	12.64	12.81	**11.43**
T5	8.22	9.50	10.64	10.41	10.96	11.37	11.69	12.11	**10.61**
T6	8.47	8.66	9.15	9.85	10.69	11.54	12.22	12.74	**10.42**
Average	**8.27**	**8.95**	**9.65**	**10.25**	**10.72**	**11.24**	**11.50**	**11.91**	**10.31**

Appendix 4. Weekly average daily milk yield (kg) of cows from both groups.

Group- I (Control)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	12.2	12.92	13.75	14.45	15.10	15.82	16.4	17.11	**14.72**
C2	11.63	12.55	13.3	13.82	14.7	15.92	16.55	16.92	**14.42**
C3	12.5	13.25	14.13	15.03	15.63	16.35	17.05	17.55	**15.19**
C4	13.9	15.2	15.91	16.68	17.41	18.33	18.75	19.22	**16.93**
C5	12.6	13.35	13.91	14.45	14.92	15.56	16.00	16.45	**14.66**
C6	12.2	12.87	13.59	14.28	15.08	15.74	16.62	17.54	**14.74**
Average	**12.51**	**13.36**	**14.10**	**14.79**	**15.47**	**16.29**	**16.9**	**17.47**	**15.11**

Group- II (Treatment)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	13.55	14.33	15.46	16.32	17.22	17.95	19.00	19.70	**16.69**
T2	13.95	14.80	15.55	16.61	17.53	18.48	19.32	20.18	**17.05**
T3	12.72	13.65	14.51	15.44	16.32	17.44	18.22	18.41	**15.84**
T4	14.00	14.78	15.62	16.55	17.41	18.32	19.13	20.00	**16.98**
T5	13.10	14.11	14.92	16.00	16.87	17.74	18.60	19.37	**16.34**
T6	12.95	13.80	14.72	15.55	16.62	17.42	18.30	19.22	**16.07**
Average	**13.38**	**14.25**	**15.13**	**16.08**	**17.00**	**17.89**	**18.76**	**19.48**	**16.50**

Appendix 5. Weekly average daily milk protein (%) of cows from both groups.

Group- I (Control)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	3.40	3.41	3.35	3.30	3.29	3.33	3.30	3.35	**3.34**
C2	3.49	3.46	3.39	3.35	3.34	3.36	3.32	3.27	**3.37**
C3	3.40	3.37	3.34	3.32	3.30	3.32	3.28	3.22	**3.32**
C4	3.38	3.36	3.45	3.41	3.38	3.29	3.29	3.25	**3.35**
C5	3.42	3.40	3.38	3.37	3.35	3.38	3.35	3.30	**3.37**
C6	3.45	3.44	3.40	3.42	3.37	3.23	3.24	3.20	**3.34**
Average	**3.42**	**3.41**	**3.39**	**3.36**	**3.34**	**3.32**	**3.30**	**3.27**	**3.35**

Group- II (Treatment)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	3.37	3.43	3.41	3.35	3.33	3.35	3.35	3.31	**3.36**
T2	3.45	3.40	3.30	3.41	3.37	3.30	3.34	3.32	**3.36**
T3	3.39	3.35	3.39	3.35	3.32	3.35	3.30	3.27	**3.34**
T4	3.34	3.38	3.33	3.34	3.33	3.30	3.31	3.28	**3.33**
T5	3.47	3.45	3.50	3.37	3.34	3.38	3.31	3.29	**3.39**
T6	3.45	3.41	3.33	3.40	3.41	3.42	3.32	3.28	**3.38**
Average	**3.41**	**3.40**	**3.38**	**3.37**	**3.35**	**3.35**	**3.32**	**3.29**	**3.36**

Appendix 6. Weekly average daily milk fat (%) of cows from both groups.

Group- I (Control)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	3.61	3.55	3.48	3.33	3.26	3.19	3.23	3.00	**3.33**
C2	3.87	3.67	3.46	3.39	3.37	3.19	3.27	3.13	**3.42**
C3	3.43	3.40	3.46	3.37	3.24	3.16	3.20	3.08	**3.29**
C4	3.63	3.50	3.43	3.47	3.42	3.23	3.28	3.14	**3.39**
C5	3.39	3.27	3.33	3.23	3.18	3.13	3.14	3.14	**3.23**
C6	3.74	3.69	3.64	3.50	3.43	3.34	3.26	3.11	**3.46**
Average	**3.61**	**3.51**	**3.47**	**3.38**	**3.32**	**3.21**	**3.23**	**3.10**	**3.35**

Group- II (Treatment)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	3.60	3.63	3.55	3.49	3.52	3.53	3.41	3.46	**3.52**
T2	3.82	3.76	3.86	3.62	3.67	3.70	3.56	3.67	**3.71**
T3	4.02	3.97	3.93	3.82	3.77	3.87	3.71	3.65	**3.84**
T4	3.27	3.20	3.18	3.26	3.23	3.17	3.20	3.24	**3.22**
T5	3.63	3.60	3.69	3.80	3.86	3.71	3.84	3.67	**3.73**
T6	3.67	3.70	3.75	3.60	3.70	3.66	3.40	3.07	**3.57**
Average	**3.67**	**3.64**	**3.66**	**3.60**	**3.63**	**3.61**	**3.52**	**3.46**	**3.60**

Appendix 7. Weekly average daily milk total solids (%) of cows from both groups.

Group- I (Control)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	11.93	12.03	11.93	11.64	11.63	11.44	11.43	11.20	**11.65**
C2	12.32	12.16	11.74	11.73	11.57	11.49	11.46	11.38	**11.73**
C3	11.95	11.95	11.94	11.79	11.69	11.53	11.52	11.40	**11.72**
C4	11.74	11.75	11.87	11.78	11.53	11.49	11.48	11.35	**11.62**
C5	11.84	11.69	11.55	11.55	11.46	11.45	11.25	11.24	**11.50**
C6	11.91	11.94	11.98	11.78	11.66	11.56	11.42	11.29	**11.69**
Average	**11.95**	**11.92**	**11.84**	**11.71**	**11.59**	**11.49**	**11.43**	**11.31**	**11.65**

Group- II (Treatment)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	12.15	12.13	11.98	11.88	11.82	11.88	11.67	11.67	**11.90**
T2	11.94	12.07	12.11	11.91	11.93	12.02	11.77	11.90	**11.96**
T3	12.34	12.35	12.26	12.26	12.10	12.16	11.92	11.83	**12.15**
T4	11.67	11.65	11.58	11.58	11.51	11.49	11.44	11.49	**11.55**
T5	12.00	11.98	12.04	12.13	12.07	11.98	12.16	11.89	**12.03**
T6	12.09	12.07	12.07	12.01	12.08	12.01	11.64	11.30	**11.91**
Average	**12.03**	**12.04**	**12.01**	**11.96**	**11.92**	**11.92**	**11.77**	**11.68**	**11.92**

Appendix 8. Weekly average daily milk SNF (%) of cows from both groups.

Group- I (Control)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	8.32	8.48	8.45	8.31	8.37	8.25	8.20	8.20	**8.32**
C2	8.45	8.49	8.28	8.34	8.20	8.30	8.19	8.25	**8.31**
C3	8.52	8.55	8.48	8.42	8.45	8.37	8.32	8.32	**8.43**
C4	8.11	8.25	8.44	8.31	8.11	8.26	8.20	8.21	**8.24**
C5	8.45	8.42	8.22	8.32	8.28	8.32	8.11	8.10	**8.28**
C6	8.17	8.25	8.34	8.28	8.23	8.22	8.16	8.18	**8.23**
Average	**8.34**	**8.41**	**8.37**	**8.33**	**8.27**	**8.29**	**8.20**	**8.21**	**8.30**

Group- II (Treatment)									
	Weeks								
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	8.55	8.50	8.43	8.39	8.30	8.35	8.26	8.21	**8.38**
T2	8.12	8.31	8.25	8.29	8.26	8.32	8.21	8.23	**8.25**
T3	8.32	8.38	8.33	8.44	8.33	8.29	8.21	8.18	**8.31**
T4	8.40	8.45	8.40	8.32	8.28	8.32	8.24	8.25	**8.33**
T5	8.37	8.38	8.35	8.33	8.21	8.27	8.32	8.22	**8.31**
T6	8.42	8.37	8.32	8.41	8.38	8.35	8.24	8.23	**8.34**
Average	**8.36**	**8.38**	**8.37**	**8.36**	**8.29**	**8.32**	**8.25**	**8.22**	**8.32**

Appendix 8. Weekly average daily milk specific gravity (%) of cows from both groups.

Group- I (Control)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
C1	1.028	1.029	1.029	1.028	1.028	1.029	1.030	1.028	**1.029**
C2	1.028	1.028	1.029	1.028	1.029	1.028	1.028	1.028	**1.028**
C3	1.028	1.028	1.029	1.029	1.028	1.028	1.028	1.028	**1.028**
C4	1.029	1.028	1.030	1.028	1.029	1.029	1.029	1.029	**1.029**
C5	1.028	1.029	1.028	1.028	1.028	1.028	1.028	1.028	**1.028**
C6	1.029	1.028	1.028	1.029	1.028	1.028	1.029	1.029	**1.029**
Average	**1.028**	**1.028**	**1.029**	**1.028**	**1.028**	**1.028**	**1.029**	**1.028**	**1.028**

Group- II (Treatment)									
Weeks									
Cows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average**
T1	1.029	1.029	1.028	1.029	1.030	1.029	1.029	1.029	**1.029**
T2	1.029	1.028	1.030	1.030	1.029	1.030	1.028	1.028	**1.029**
T3	1.030	1.030	1.029	1.030	1.030	1.029	1.029	1.028	**1.030**
T4	1.030	1.029	1.030	1.030	1.030	1.029	1.030	1.029	**1.030**
T5	1.029	1.030	1.030	1.029	1.029	1.030	1.029	1.028	**1.030**
T6	1.030	1.029	1.030	1.029	1.030	1.029	1.029	1.028	**1.030**
Average	**1.030**	**1.029**	**1.030**	**1.030**	**1.030**	**1.029**	**1.029**	**1.028**	**1.029**

Appendix 9. Fortnighty average body condition score (BCS) prepartum cows.

Group- I (Control)				
Fortnightly				
Cows	**1**	**2**	**3**	**Average**
C1	3.75	3.75	3.75	**3.75**
C2	3.50	3.50	3.25	**3.42**
C3	3.50	3.50	3.25	**3.42**
C4	3.75	3.75	3.75	**3.75**
C5	3.75	3.50	3.50	**3.58**
C6	4.00	4.00	3.75	**3.92**
Average	**3.71**	**3.67**	**3.54**	**3.64**

Group- II (Treatment)				
Fortnightly				
Cows	**1**	**2**	**3**	**Average**
T1	3.75	3.75	3.75	**3.75**
T2	3.25	3.25	3.25	**3.25**
T3	3.50	3.50	3.50	**3.50**
T4	3.75	3.75	3.50	**3.67**
T5	4.00	4.00	4.00	**4.00**
T6	3.75	3.75	3.75	**3.75**
Average	**3.67**	**3.67**	**3.63**	**3.66**

Appendix 9. Fortnighty average body condition score (BCS) postpartum cows.

Group- I (Control)					
Fortnight					
Cows	**1**	**2**	**3**	**4**	**Average**
C1	3.50	3.50	3.25	3.00	**3.31**
C2	3.25	3.00	2.75	2.75	**2.94**
C3	3.00	3.00	2.75	2.50	**2.81**
C4	3.50	3.50	3.25	3.00	**3.31**
C5	3.25	3.25	3.00	2.75	**3.06**
C6	3.50	3.25	3.00	3.00	**3.19**
Average	**3.33**	**3.25**	**3.00**	**2.83**	**3.10**

Group- II (Treatment)					
Fortnight					
Cows	**1**	**2**	**3**	**4**	**Average**
T1	3.50	3.50	3.25	3.25	**3.38**
T2	3.00	3.00	2.75	2.75	**2.88**
T3	3.25	3.25	3.00	3.00	**3.13**
T4	3.50	3.25	3.25	3.00	**3.25**
T5	3.75	3.75	3.50	3.50	**3.63**
T6	3.50	3.50	3.25	3.25	**3.38**
Average	**3.42**	**3.38**	**3.17**	**3.13**	**3.27**

Appendix-G

THESIS ABSTRACT

a)	Title of the thesis (in Capital letters)	:	EFFECT OF SUPPLEMENTATION OF BYPASS FAT DURING PRE AND POST PARTURIENT PERIOD ON LACTATION PERFORMANCE OF CROSSBRED COWS
b)	Full name of student	:	RUMNE ABHINEET ASHOK
c)	Name and address of Major Advisor	:	Dr. B.N. Ramteke Associate Professor, Department of Animal Nutrition, Bombay Veterinary College, Parel, Mumbai- 4000 12
d)	Degree to be awarded	:	M. V. Sc.
e)	Year of award of degree	:	2015
f)	Major subject	:	Animal Nutrition
g)	Total number of pages in the thesis	:	86
h)	Number of words in the abstract	:	693
i)	Signature of Student	:	
j)	Signature, Name and address of forwarding authority (HOD / SH)	:	
	Signature of the Associate Dean	:	

ABSTRACT

The present study was undertaken to assess the effect of bypass fat supplementation during pre and post parturient period on lactation performance of crossbred cows under field condition. The effect of bypass fat supplementation was evaluated in terms of milk production, milk composition, efficiency of feed utilization in terms of DM, DCP and TDN intake per kg FCM yield, body condition score and economics of milk production.

For this trial, twelve crossbreed Holstein Friesian cows were selected. The selected cows were divided into two groups of six each. The animals were selected on the basis of daily milk yield, gestation period and lactation number. The average daily milk production was 10-11 kg/day/animal and in 3-4 lactation stage. The average stage of pregnancy of selected cows was around 30-35 days before parturition. The group I served as control and received concentrate mixture as per routine practice of the farm. The group II served as treatment and was fed with same concentrate mixture as used in the farm, supplemented with bypass fat @ 30 gm/100 kg body weight for a period of one month before parturition to two months after parturition. The ingredient composition of concentrate mixture was 30 kg ground maize, 32 kg cottonseed cake, 35 kg wheat bran, 2% mineral mixture and 1% salt. All the animals from both experimental groups received lucerne and guinea grass as a source of roughage. The trial lasted for thirteen weeks.

The average weekly daily dry matter intake of prepartum cows was 8.37 and 8.40 kg, for the control and treatment group, respectively while that of postpartum cows was 10.12 and 10.31 kg, respectively. The dry matter intake was non-significant between treatment and control groups. The average daily milk yield of cows from control and treatment group was 15.11 and 16.50 kg, respectively. The average weekly daily milk yield of bypass fat supplemented group was significantly ($P<0.01$) higher as compared to control.

The milk production on FCM basis was higher for treatment group (15.48 kg) than control (13.61). The average daily TDN and DCP intake of cows in treatment group receiving bypass fat was significantly higher than control group during prepartum and postpartum stage. The average DM required per kg FCM production for cows from control and treatment was 0.74 and 0.67 kg,

respectively. The daily DM intake per kg FCM produced was more efficient (P<0.01) in treatment group than control. The average TDN required per kg FCM production for cows from control and treatment group was 0.49 and 0.46 kg and DCP required per kg FCM was 0.075 and 0.069 kg, respectively. The average daily TDN and DCP intake per kg FCM produced was significantly (P<0.01) higher in treatment group as compared to control group.

The weekly average milk protein and fat percentages were 3.35% and 3.36% and 3.35% and 3.60% for control and treatment group respectively. The average milk protein% was non-significant between both the experimental groups. The average fat % was significantly (P<0.01) higher in bypass fat supplemented group than control. The weekly average milk SNF and total solid were 8.30 and 8.32 and 11.65 and 11.92 for control and treatment group, respectively. The average milk SNF was non-significant between both the groups and total solid were significantly (P<0.01) higher in treatment group than control group. The weekly average specific gravity was significantly higher (P<0.01) for treatment group (1.029) than control (1.028). The fortnight average body condition score was non-significant during prepartum phage among control (3.64) and treatment (3.66) group, while significantly higher (P<0.05) during postpartum phage in the treatment group (3.27) as compared to control (3.10).

The average digestibility coefficients for all the nutrients were numerically higher for cows receiving bypass fat supplementation, as compared to control. The TDN and DCP content for control and treatment group were 66.65 and 68.95 and 10.16 and 10.30, respectively. The economics of the study revealed net extra profit of ₹33.09/- in treatment group over control group.

Thus it is inferred that bypass fat supplementation @ 30 gm/100 kg body weight is beneficial for maintaining the health of animal during critical transition phase, increasing milk production and feed efficiency thereby increasing the profit in dairy business.

Appendix-G

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7-	izca/kkph ,dq.k i`"Bla[;k	%	
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VITA

Mr. Rumne Abhineet Ashok was born on 9th June at Dist-Latur, Maharashtra state. He finished his lower education at Baswanappa Whale English School and secured 60.93% (first class) in S. S. C in the year 2003. For further studies he was admitted in Jai Kranti college, Latur and passed with 67.50% in H. S. C in the year 2005. He joined Nagpur Veterinary College, Nagpur as an undergraduate student in year 2005 and completed his graduation securing 78.10% in the year 2010 securing. Due to his interest in Animal Nutrition he gained admission in the Department of Animal Nutrition of Bombay Veterinary College in October 2013.

His efforts resulted in the submission of the present thesis successfully. As part of his training in the Department of Animal Nutrition he assisted various research works.

As an all rounder student he participated in National Service Scheme, and free animal treatment Camps. He was also Sergent of Road Safety Patrol division in 6th standard in 2000. He had hold the responsibility of rank Sergent of Army wing during his undergrate carrer at Nagpur veterinary college and represented his college at Delhi during Republic Day Camp in 2008 in the event of Horse riding drill march on Rajpath. His passion for music was acknowledged during his childhood by his school principle for which he was selected for assisting school orchestra.

He sees himself as the Poll-Bearer and trouble-shooter of the Veterinary profession, particularly in the field of nutrition of the animals in the years to come.