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Review Article

# Effects of Bypass Fat and Prilled Fat Supplementation on Nutrition and Performance in Milch Animals: A Review

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## Abstract

*Bypass fats (BF) are usually referred to as escape fat, ruminal inert fat or protected fat and are more costly per unit of energy provided compared to commodity fats. BF and prilled fat (PF) supplementation are a viable option to mitigate negative energy balance (NEB) and also to improve high yielding lactating animal performance. Supplementation of fat with calcium salts of long chain fatty acids approach is a good method for increasing energy density of the diet and to improve milk yield, fat content and reproductive performance but it partially degrades in the abomasum and on the other hand prill fat (PF), a bypass fat available in different forms augments productive performance of lactating animals by getting digested only in the small intestine. It is a well-established fact that inclusion of energy as unprotected fat higher than 3-4% cause physical and chemical changes in the microbial fermentation in rumen resulting in decrease in microbial activity and depression in cellulose digestibility. Hence, inclusion of the fat in ration of lactating animals which is resistant to bio-hydrogenation by rumen microbes reduces the risk of metabolic acidosis and later on gets digested in lower digestive tract. Adding protected fat to dairy rations positively affect the efficiency through a combination of calorific and non-calorific effects.*

**Keywords:** Bypass Fat, Dairy Diet, Milch Animals, Prilled Fat, Prill Fat

## Introduction

Majority of the diets fed to the milch animals in tropical countries are dominated by crop residues which are low in energy, protein and minerals. For the high yielding dairy animals negative energy balance (NEB) during early lactation is common, consequent to the energy loss associated with milk fat secretion and the initial post-partum decline in feed intake. Measures to substantiate the NEB by adding high levels of cereal grains etc. to support milk production may not be a feasible strategy as too much proportion of concentrate mixture beyond 60 percent will decrease fibre digestibility, causes rumen acidosis, lowers milk yield and milk fat percentage (Thakur and Shelke, 2010).

Productivity of lactating animals can be enhanced by strategic supplementation with energy and the energy density of the total diet by incorporating fat in their diet (Sirohi *et al.*, 2010). Inclusion of energy as unprotected fat higher than 3-4% cause physical and chemical changes in the microbial fermentation in rumen resulting in decrease in microbial activity and depression in cellulose digestibility. It was suggested to include fat in ration of lactating animals which is resistant to bio-hydrogenation by rumen microbes and also reduces the risk of metabolic acidosis (Naik *et al.* 2009b; Block *et al.*, 2005). In this context application of the dietary fat as bypass fat (BF) or rumen protected fat or inert fat that resists lipolysis and biohydrogenation in rumen-by-rumen microorganisms, but gets digested in lower digestive tract is the alternative. In high producing dairy animals, the role of the bypass fat in the rations is very critical for improving the energy density of ration (NRC, 2001).

The present review focuses on the uses and results of supplementing the fat as bypass fat and prilled fat (PF) (a non-hydrogenated vegetable oil having more than 85% palmitic acid and having high melting point). High melting point feature of the prilled fat or prill fat helps the bypass of rumen degradation process and does not affect feed intake but broken down in the intestine by lipase enzyme and in turn enhances milk production performance in cows and buffaloes (Rajesh, 2013; Singh, S., 2015). It has also been reported that supplementation of prilled fat during mid-lactation improved milk production and reproductive performance in crossbred cows (Singh *et al.*, 2014).

## Nutrition

### Effect on Feed Intake, Dry Matter & Organic Matter Digestibility

#### *Dry Matter Intake (DMI)*

Supplementation of rumen protected fat did not affect dry matter intake (DMI) of dairy cows (Thakur and Shelke, 2010 and Silvestre *et al.* 2011). While Shelke *et al.* (2012) and Naik *et al.* (2009b) observed no effect on DMI in buffaloes. Ranjan *et al.* (2013) in a study on buffaloes fed with bypass fat @100 g/day and 200 g/day for 90 days reported that additional bypass fat supplementation did not affect the DMI in control and treatment group. The DMI during the 90 days experimental period in buffaloes fed rumen protected fat @ 0.7% and 1.4% of the diet was similar to the control group (Ranjan *et al.* 2012). Singh et al. (2014) reported that on feeding prilled fat @ 75 g/d to crossbred cows did not influence the DMI of the animals. Shelke *et al.* (2011) studied the effect of pre partum rumen protected fat and protected protein supplementation on the performance of Murrah buffaloes between 2$^{nd}$ to 4$^{th}$ lactation and it was observed that the average DMI was 11.13 and 11.69 (kg/d) in control and treatment group respectively, which was significantly ($P<0.05$) higher in supplemented group. Here the increase in DMI was ascribed to the fact that the added inert fat was likely to be largely unavailable in the rumen because of its low solubility and high melting point, thereby not impairing rumen fiber digestibility and avoiding an increase in gut fill that can limit dry matter intake (Purushothaman *et al.*, 2008).

The variation in DMI of animals fed with bypass fat is attributed to its level of incorporation in the diet, palatability, and status of the lactating animals (Naik *et al.*, 2009b). Also, Srivastava and Mudgal (1990) showed that an optimum level of dietary fat would ensure maximum DM intake. Weiss and Wyatt (2004) reported a significant decrease in DMI on supplementing Ca salts of palm fatty acids at 3.4% of DMI.

#### *Dry Matter Digestibility (DMD) and Organic Matter Digestibility (OMD)*

The fat supplementation has a profound negative effect on DMD and OMD through the impact on dietary fibre digestion, if it is more than 5-6 % of DM intake. The main hypothesis behind the protection of fat was to overcome this deleterious effect of fat supplementation on fibre digestion and utilizing the beneficial effect of increased energy density of the ration. No significant differences (P>0.05) in DMD were noted in buffaloes fed with diets containing poultry fat or mustard oil than control diet (Nawaz *et al.*, 2012). Average digestibility coefficients for OM were higher (P<0.01) in buffaloes fed diets containing tallow and poultry fat than control diet or the diet supplemented with mustard oil.

Shelke *et al.* (2012) investigated the effect of feeding of protected fat and protected protein on milk production, composition and nutrient utilization in Murrah buffaloes. Buffaloes in control group (C group) were fed chaffed wheat straw, chopped maize fodder and concentrate mixture as per requirements. Buffaloes in supplemented group (S group) were fed same ration as C group plus 2.5% rumen protected fat (on dry matter intake basis) and formaldehyde treated mustard and groundnut oil cake (1.2 g formaldehyde/100 g crude protein) in place of unprotected cakes. Group S buffaloes were supplemented rumen protected fat and protein 60 days pre-partum to 90 days postpartum. There was no difference of digestibility coefficients (g/g) of dry matter and organic matter between the groups. Ranjan *et al.* (2013) reported the nutrient digestibility of different nutrients i.e., DM, OM, EE, CF, CP, NFE and it was observed that the DM and OM were higher in treated groups fed 100 and 200 g/d of rumen protected fat compared to control, however, there was no significant difference between the groups.

On the basis of literature cited, it is evident that the source and method of preparation of rumen protected fat has more impact on nutrient digestibility than the supplementation level in the normal ration of lactating ruminants.

## Performance

### Effect on Body Weight (BW)

Fat or lipids if moved from body reserves will significantly contribute towards the energetic cost of milk produced in the early lactation. During a lactation cycle, dairy cows are successively mobilizing and storing body reserves, independent of the requirement for milk production. In high milk producing cows the approximate amount of body fat mobilized to meet the energy shortage was above 50% of milk fat output over the first five weeks of lactation. During the first 16 weeks of lactation, when the cows were in NEB, they mobilized 50 to 60 kg of fat –about 10% of their BW and probably at least 50% of their total adipose lipid reserves.

Feeding of fat is done to minimise the body weight loss and hasten the body weight gain while maintaining milk production in dairy animals. Vahora *et al.* (2013) observed that the feeding of ca salt of palm oil fatty acids reduced loss in body weight compared to control animals. In contrast, Purshothaman *et al.* (2008) and Ganjkhanlou *et al.* (2009) reported no significant effect of feeding Ca salt of palm oil fatty acids on body weight change in dairy cows.

Naik *et al.* (2009b) reported better recovery in the body weight and body condition score in crossbred cows during early lactation in BF supplemented group. In another study by Wadwa *et al.* (2012) the body weight of the animals improved considerably in the BF supplemented group as compared to control (551 vs. 508 kg), but the differences were non- significant.

Sirohi *et al.* (2010) observed no change in BW of lactating cows when the animals were fed BF. Effect of supplemental calcium long chain fatty acids (Ca-LCFA) on change of BW is influenced by parity of animal. Singh *et al.* (2014) reported that difference in body weights of crossbred cows were non-significant (P>0.05) between two groups fed without or with PF @ 75 g/d during mid lactation.

### Effect on Milk Yield and Milk Composition

#### *Milk Yield (MY)*

In a study on Murrah buffaloes, Thakur and Shelke (2010) reported an improvement of 12.4% in MY of buffaloes fed 4 % Ca salts of fatty acids. Tyagi *et al.* (2009a) reported that BF supplementation at 2.5% of DMI for 90 days postpartum increased the milk production and its persistency up to 120 days after cessation of protected fat feeding.

Schroeder *et al.* (2004) reported that mid-lactation cows had a higher MY response to fat supplementation than early lactation cows, and it has been suggested that the maximum milk production response to the supplemental fat is only achieved when cows were in positive energy balance state. The feeding of PF @75g/day for a period of 90 days resulted in a significant increase in milk yield (P<0.05) in comparison to control group cows (Singh *et al.*, 2014). Ranjan *et al.* (2013) reported higher milk yield in buffaloes at supplementation of l.4 % of rumen protected fat when compared on the basis of 6.5% FCM. FCM yield has been reported to increase by feeding of protected fat to crossbred cows (Sirohi *et al.* (2010), Thakur and Shelke (2010); Shelke *et al.*, 2012). Gowda *et al.* (2013) reported that milk yield was significantly (P<0.01) higher (19.1 vs 17.8 L/cow/day) in cows supplemented with protected fat with area specific mineral mixture (ASMM). Thakur and Shelke (2010) reported that average milk yield in experimental group was higher by 12.43% over that of control group when this group was fed with additional Ca salts of soya acid oil fatty acids supplemented at 4% of DMI. Higher peak yield and milk production observed in experimental group may be attributed to enrichment of ration with Ca salts of soya acid oil fatty acids that increased the energy density of the ration.

Naik *et al.* (2009b) and Shelke *et al.* (2012) found an increase in milk yield by 19% (P<0.01) in supplemented group than control with bypass fat inclusion. Wadhwa *et al.* (2012) assessed the effect of supplementation of bypass fat (BPF) on the performance of high yielding crossbred cows in their early lactation. The animals in the control group (C) were offered ad lib homemade concentrate mixture and non-leguminous green fodder for 180 days. The animals in the experimental group were offered ad lib control diet, supplemented daily with 150–200g 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 group with an increase in protein, lactose and SNF content in milk, without effecting milk fat content as compared to control group. Singh *et al.* (2014) observed that milk yield was significantly higher in prilled fat fed group @ 0.71kg/d as compared to control and also the milk yield of cows remained higher even after the withdrawal of prill fat feeding in crossbreed cows during mid lactation.

***Milk Composition***

Effect of supplemental Ca-LCFA on milk composition is dependent upon breed, parity, stage of lactation of animal; level of supplementation and FA composition of Ca-LCFA. Among milk components, fat content is the most sensitive to dietary changes. Milk protein is more sensitive to diet than lactose, but is responsive than fat (Jenkins and McGuire, 2006). The milk lactose concentration provides only little indication of energetic balances, because the lactose content in milk of healthy dairy cows is nearly constant (McNamara *et al.*, 2003b). BF increased the levels of unsaturated fatty acids and long chain fatty acids in milk fat (Tyagi *et al.*, 2009a; Thakur and Shelke, 2010; Shelke *et al.*, 2011).

Shelke *et al.* (2012) reported that milk fat was higher (P<0.01) by 5.43% in bypass fat supplemented groups than that of control group (8.15% vs 7.73%) but total solids, milk protein, SNF and milk lactose (g/100 g) contents of milk were statistically similar. Sirohi *et al.* (2010) observed that milk fat percentage differed significantly (P<0.01) whereas milk protein and SNF were similar between bypass fat fed and the control groups. Milk fat per cent showed a clear-cut rise with the bypass fat supplementation (Mishra *et al.*, 2004; Garg *et al.*, 2008). Thakur and Shelke (2010) reported the average milk fat % was higher (P<0.05) in experimental group than that of control when treatment group was fed with additional Ca salts of soya acid oil fatty acids supplemented at 4% of DMI. There was no effect on protein, total solids and SNF contents of milk between the groups. Same results were reported by other researchers who observed improvement in milk fat but no effect on protein, Total solids and SNF contents on addition of bypass fat (Sklan *et al.*, 1994; McNamara *et al.*, 2003b). Wadhwa *et al.* (2012) investigated the effect of supplementation of bypass fat (BPF) on the performance of high yielding crossbred cows in their early lactation. The animals in the control group (C) were offered ad lib. concentrate mixture and non-leguminous green fodder for 180 days. The animals in the experimental group were offered ad lib. control diet, supplemented daily with 150–200g 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 group with an increase in protein, lactose and SNF content in milk, without effecting milk fat content as compared to control group.

Ranjan *et al.* (2012) found that milk fat, protein, SNF, and total solid contents were also similar among the different groups of animals. Singh *et al.* (2014) observed that milk yield was significantly higher in prilled fat fed group @ 0.71kg/d as compared to control and also the milk yield of cows remained higher even after the withdrawal of prill fat feeding in crossbreed cows during mid lactation. The feeding of prilled fat @75g/day for a period of 90 days resulted in a significant increase in milk yield (P<0.05) and decreased fat and SNF content without affecting lactose, protein, milk cholesterol in comparison to control group cows.

***Milk Fat***

Fat is the single most constituent of milk that has received the greatest attention worldwide. This is because the fat concentration is most sensitive to dietary changes, can be changed over the widest range compared to other solids like protein and lactose and lastly it was the first constituent to be widely used as a basis for deciding the unit price of milk, and so in India.

A change in milk fat concentration is achieved by altering either the level of initial synthesis in mammary gland or the supply of LCFA in the diet. To a large extent, most effects on milk fat concentration are mediated through the management of rumen fermentation. Sutton *et al.* (1988) reported that the fibre quantity and quality, forage to concentrate ratio, buffer inclusion, concentrate composition and concentrate feeding frequency will form the dietary factors that affect the supply of acetic acid from the rumen de novo synthesis. The effects of fat supplements on milk fat content are highly variable and always the feeding of BF increases milk fat concentration.

Sirohi *et al.* (2010) studied effect of BF supplementation on nutrient utilization and production performance. Cows were fed wheat straw, concentrate mixture and green maize fodder in the control group and additional 300 g BF was given in treatment group. The average MY and FCM per day was significantly higher in treatment group. Milk fat and total solids content were enhanced significantly in treatment group, whereas milk protein and solids-not-fat (SNF) remained unaltered in both groups. Wadhwa *et al.* (2012) assessed the effect of supplementation of bypass fat (BPF) on the performance of high yielding crossbred cows in their early lactation. The BPF supplementation did not show any impact on milk fat as compared to control group but an increase in protein, lactose and SNF content in milk was observed. McNamara *et al.* (2003) observed no significant difference after supplementing megalac plus (0.4 kg/ d) and megapro gold (1.5 kg/ d) on milk fat yield in cows. Ranjan *et al.* (2012) also observed no change in the milk fat on feeding by pass fat to buffaloes.

***Milk Protein***

Protein based pricing of milk in the United States is well established since 1989. A premium is offered for milk with more than 3.25% protein. As more milk is used for cheese production, component pricing of milk is very important. Consequently, dietary strategies to maintain, if not increase, milk protein percentage is becoming an economic imperative. Decrease in protein (casein) percentage of milk is undesirable because casein is not only the major protein of milk (75-78%); it is also the major protein in curd formation (De Peters *et al.,* 1989). This is important with respect to cheese making characteristics.

There have been four possible reasons attributed to decreased milk casein percentage on feeding supplemental fat. There is a reduced microbial protein synthesis (Dunkley *et al.,* 1977), restricted availability of glucose, Insulin resistance by the mammary gland impairs amino acid transport and milk protein synthesis (Palmquist and Moser, 1981), a reduced release of bovine somatotropin from the anterior pituitary reduces mammary gland uptake of amino acids (Casper and Schingoethe, 1989). However, many workers have reported a non-significant effect of rumen protected fat supplementation on milk protein content. Veth *et al.* (2005) reported no effect on protein yield on supplementing Ca salts and formaldehyde protected conjugated linoleic acid. Purushothaman *et al.* (2008) observed no change in protein content in milk of cows when the animals in groups 1(control), 2, 3 and 4 were fed concentrate mixture containing 0 (no bypass fat), 2, 4 and 6% bypass fat, respectively. Sirohi *et al.* (2010) observed that milk protein content of crossbred cattle did not differ significantly between bypass fat fed and the control groups.

Some authors have also reported an increase in milk protein content on supplementing rumen protected fat. Teh *et al.* (1994), on feeding rumen inert fat at 0, 3, 6 and 9% level, reported highest protein content at 6% level. Similarly, enhanced milk protein content was observed by Sklan *et al.* (1994) on supplementing calcium soaps of FA and Sampelayo *et al.* (2004) on a PUFA rich protected fat supplement.

## Reproductive Performance

Animal nutrition according to the feeding standards ensures optimal reproductive performance of dairy animals along with good economic returns to the milk producers. There is a direct association of reproductive performance of animals with the dietary energy intake and body condition (Aguilar-Perez *et al.,* 2009). Lower dietary energy intake and poor body condition can negatively affect reproductive performance of dairy animals, which results in lower economic returns to the milk producers.

Reproductive disorders are one of the major factors reducing the milk and affecting the production potential of dairy animals. Therefore, it is desirable to incorporate the recent innovations i.e., protected fat in the ration of lactating cows in their early lactation period to avoid the NEB and to enhance the milk productivity with desirable composition, which may subsequently have far reaching positive influence on their reproductive performance. Supplementation of the BF to the milch animals positively promotes the reproductive functions with regard to ovary, uterus, hypothalamus and anterior pituitary. The BF composition and the source of the fat also affects the reproductive performance of animals, while affecting the target tissues.

Dietary supplementation of Ca-LCFA has positive effect on reproductive performance of dairy cows, which is further dependent upon the specific FA profile. Dietary supplementation of Ca-LCFA reduces number of artificial inseminations required per conception (Naik *et al.,* 2009b). However, changes in reproductive performance associated with fat supplementation are related to magnitude of milk response of fat supplementation (Scott *et al.*, 1995).

Initially supplementation of BF or PF was used as energy source during the transition period leading to improvement in reproductive performance, but later it was realised that the Fatty Acids in the BF were acting as the precursor of progesterone synthesis via cholesterol and prostaglandins pathway (Staples *et al.,* 1998). The reported improvement from added fat includes improved conception rate (Ben-Salem and Bouraoui, 2008; Tyagi *et al.,* 2010), increased pregnancy rate and reduced service period (Beaver, 2006). Feeding BF @ 100-150 g per day to high yielding milch animals during the transition period i.e., before ten days and after ninety days of calving) may improve the milk yield and reproduction efficiency (Garg *et al.,* 2008). The beneficial effects on reproductive responses may be due to a hastened restoration of the post-partum reproductive system to support embryo development.

## Conclusion

Bypass fat and prilled fat (PF) supplementation can be concluded as a viable option to mitigate negative energy balance (NEB) and also to improve high yielding lactating animal performance. In addition to the above works, for a complete understanding and to derive on to near- and long-term solutions for the high milk yielders, a better knowledge of the advantages and disadvantages of the Bypass fat and prilled fat as feed additive or supplementation and also its substitution is required along with further laboratory and field studies.

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## Conflict of Interests

There is no conflict of interest.

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