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EFFECT OF BALANCED FEEDING ON SNF CONTENT OF MILK: A FIELD STUDY

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ABSTRACT

A study was undertaken to assess the impact of feeding a balanced ration on the SNF content of milk and production performance in crossbred cows in Kozhikode district. Out of 133 animals screened, 73 crossbred cows were identified with low SNF. Milk yield, milk fat, SNF and net daily income of milk producers were recorded before and after feeding a balanced ration. Nutritional status of animals indicated that about 37% of the animals had either deficiency of protein or energy in the ration, whereas, ration of 100% of the animals was deficit in calcium and phosphorus. On feeding a balanced ration for 8 weeks, there was significant improvement in SNF content of milk from 7.93 to 8.93% in cows. Average daily milk yield and milk fat increased from 10.36 to 11.67 kg and 3.98 to 4.35%, respectively. This translated into an additional daily monetary benefit of about Rs. 44 per animal to the milk producers. Rumen microbial protein and levels of serum immunoglobulins increased, on feeding a balanced ration. The study demonstrated that feeding a balanced ration not only helped in improving SNF content of milk, but also resulted in improving daily income of small-holder milk producers.

INTRODUCTION

Milk comprises two components, fat and SNF, the latter stands for Solids-Not-Fat i.e. apart from fat all other solids, like lactose, protein, minerals and vitamins. Food Safety and Standards Authority of India (FSSAI) has fixed a limit of 8.5% SNF in cow milk, in most of the states of India. The price of milk is determined by its fat and/or SNF content. Milk producers on many occasions are informed about low SNF content in their milk, when they go to village based dairy cooperative society for selling their produce. On account of low SNF content, there are heavy deductions in payments to milk producers. At times even the milk is rejected altogether. Milk producers have hardly an alternate option to dispose of rejected milk. Many agencies from different parts of the country keep sending representations to FSSAI for lowering standard for SNF content in milk (FSSAI, 2013). Fat and SNF plays an important role in physico-chemical, sensory, textural characteristics and also the shelf life of any milk based sweet (Chaudhary *et al.,* 2015). Quality and quantity of milk are determined by the genetics and the feeding practices. No breed improvement programme world over would ever support low SNF content in milk. Of all the factors affecting milk composition, nutrition and feeding practices are most likely to cause problem (Garg *et al*., 2016).

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The possible reason for low SNF in milk in field animals could be on account of deficiency of various critical nutrients such as energy, protein and/or minerals (Rook and Line, 1961; Annison and McDowell, 1977; Garg, 2012) or adulteration with water (Bendale *et al*., 2015). Nutrition of the dairy cow affects the yield and proportion of milk components. Through the diet, the mammary gland is supplied with blood components to synthesize milk. Therefore, present study was undertaken to investigate the nutrient status of field animals having low SNF in milk and whether or not the correction of such deficiencies help in achieving the improvements. The results of the study are reported in the following section.

MATERIALS AND METHODS

Location of the study

Kozhikode is one of the fourteen districts and a very important dairying district of Malabar region in Kerala state. Kozhikode district is located on the South-West Coast (Malabar Coast) of India. Kozhikode district is bordered by the districts of Kannur to the North, Wayanad to the East, and Malappuram to the South. The Arabian Sea lies to the West. It is situated between latitudes 11° 08'N and 11° 50'N and longitudes 75° 30'E and 76° 8'E.

Selection of animals, diets and management

Out of 133 animals screened, 73 crossbred cows were identified with low SNF from Kodenchery and Puthuppady villages of Kozhikode district. Prevailing feeding practices and SNF content in milk were measured right at the milk producers' doorstep for three consecutive days. The representative sample of feeds and fodder offered to individual animal was taken for proximate principles. Thereafter, the ration of all animals was balanced for crude protein, metabolizable energy (ME), calcium and phosphorus, using the ration balancing software developed by National Dairy Development Board (NDDB), which is based on NRC (2001) standard for cattle. The balanced ration was fed to all the animals for 60 days. The body weight of the animals were calculated using Shaeffer's formula: Body weight (kg) = [(heart girth in inches)^2 x length of the body in inches] x 0.4536. After balanced feeding, milk yield and fat per cent were recorded daily, whereas, SNF content in milk was measured on weekly basis. Blood and urine samples were also collected before and after feeding a balanced ration for measurement of different parameters.

Laboratory analysis

Feeds and fodder samples were analyzed for proximate composition by AOAC (2005) methods. The milk sample were analysed for fat and SNF, using FOSS MilkoScan^{TM} minor type 78110. Blood samples were collected from the jugular veins in air-tight vacutainer tubes using dehydrated EDTA from individual animals prior to feeding and frozen for blood biochemical analysis. The samples were analyzed for protein, glucose, triglycerides, creatinine, NEFA, Ferric Reduction Anti-oxidant Power (FRAP) activity (Benzie and Strain, 1996) and immunoglobulins (IgG, IgM, IgA and IgE), by using kit supplied by DiaSys Diagnostic Systems GmbH (Germany). Urine (100 ml) samples were collected from individual cows and preserved with sufficient quantity of 10% H_2SO_4 to maintain pH below 3. The urine samples were diluted in such a way that the concentration in the final sample would fall within the range of standards used in the assays for estimation of purine derivatives (IAEA, 1997). The urine samples were assayed for allantoin, uric acid and creatinine (Young and Conway, 1942; Hawk *et al.*, 1976). Purines absorbed and microbial N supply was calculated from the daily urinary purine derivatives excreted (IAEA, 1997).

Statistical analysis

Statistical analysis of the data was carried out by Student's'*t*' test as per Snedecor and Cochran (1994) with SPSS package programme (SPSS 9.00 software for Windows, SPSS Inc., Chicago, IL).

RESULTS

Feeding practices and nutritional status of the animals

It was observed that compound cattle feed (CP: 20%; EE: 2.5%) and locally available green grasses were the most commonly used concentrates and roughage sources for dairy cows by the milk producers in Kozhikode district of Kerala. Milk producers also fed wheat bran, coconut cake, groundnut cake, rice bran and tapioca starch waste to their animals. Straw of rice was used as a sole source of dry roughage.

Analysis of feeding practices revealed that average metabolic body weight was not affected, however, dry matter intake increased significantly (p<0.05) on feeding a balanced ration (Table 1). Nutritional status of the lactating cows in the villages under the study is given in Table 2. It was found that about 37% of the animals had either deficiency of crude protein (CP) or metabolizable energy (ME) compared to their requirements, whereas, calcium (Ca) and phosphorus (P) were deficient in 100% of the animals.

Milk yield and milk fat

On feeding a balanced ration, there was increase (P<0.01) in daily milk yield and milk fat from 10.36 to 11.67 kg and 3.98 to 4.35%, respectively (Table 3). The 4% FCM was increased from 10.22 to 12.27 kg/day.

SNF content of milk

On feeding a balanced ration for 8 weeks, there was significant improvement (P<0.01) in SNF content of milk from 7.93 to 8.93% (Table 3). It was observed that there was initial improvement in SNF content, but it stabilised after 1-2 weeks. The animals continued fed on balanced ration for 6 weeks. There was again increase in SNF content after 4th week and reached to normal.

Feed conversion efficiency

Milk production is directly related with feed conversion efficiency (FCE). FCE is a measure of converting nutrients into milk and is measured in kg of milk produced per kg of DM consumed from the feed. Data revealed that feeding balanced ration significantly improved the FCE and profit from increase in milk and fat yield. The FCE, as kg of fat corrected milk (FCM) kg/kg DM intake before and after feeding a balance ration was 0.92 and 0.99, respectively. Efficiency of utilization of dietary protein for milk production also improved after feeding a balanced ration in cows (Table 3). There was also reduction in feeding cost from Rs. 14.31 to 12.93 per kg of milk yield. On an average, there was increase in daily milk yield by 1.31 kg/animal and milk fat by 0.37%. This translated into a daily monetary benefit of about Rs. 44 to the milk producers.

Blood parameters

Levels of serum immunoglobulins like IgG, IgM and IgA (mg/ml) increased from 21.50 to 23.69, 3.02 to 3.30 and 0.47 to 0.55, respectively, whereas, level of serum IgE (pg/ml) reduced from 560 to 470, on feeding a balanced ration. There was significant increase in protein level in blood, whereas, levels of glucose, triglycerides, creatinine, NEFA were not affected, on feeding a balanced ration (Table 4).

Microbial protein synthesis

Microbial N yield (g CP/day) increased significantly (P<0.01) from 700 to 1121, after feeding a balanced ration (Table 5).

DISCUSSION

This study has demonstrated successful implementation of ration balancing programme approach involving small holder farms under field conditions, in developing countries and its effects on different parameters.

Table 1. Effect of ration balancing (RB) on plane of nutrition of lactating cows

Particular	Before RB (n=73)	After RB (n=73)
Body weight (kg)	423.32±2.97	425.96±2.95
Metabolic body weight (kg $W^{0.75}$)	93.29±0.49	93.73±0.49
DM intake (kg/day)	11.22^{a} ±0.26	12.41^{b} ±0.25
Concentrate: Roughage ratio	51:49	47:53
DM intake (kg/100 kg body weight)	2.70±0.06	2.98±0.06
CP intake (g/day)	1442^{a} ±47.57	1513^{b} ±50.61
TDN intake (kg/day)	6.66^{a} ±0.17	7.39^{b} ±0.17

^{c,d}values with different superscripts in a row within respective parameter differ (P<0.05)

Table 2. Nutritional status of the lactating cows in the villages of Kozhikode district

Nutritional status	No. of animals	Nutritional status	No. of animals
Excess in CP and ME	18 (24.65%)	Excess in Ca and P	0
Deficient in CP and ME	28 (38.35%)	Deficient in Ca and P	73 (100%)
Excess in CP and def in ME	27 (37%)	Excess in Ca and def in P	0
Deficient in CP and excess in ME	0	Deficient in Ca and excess in P	0

Figures in the parentheses indicate % deficiency in the ration.

Table 3. Effect of ration balancing (RB) on milk production, fat and SNF content of milk

Parameter	Before RB (n=73)	After RB (n=73)
Milk yield (kg/day)	10.36^{a} ±0.50	11.67^{b} ±0.49
Milk fat (%)	3.98^{a} ±0.08	4.35^{b} ±0.06
4% FCM (kg/day)	10.33^{a} ±0.55	12.27^{b} ±0.53
SNF (%)	7.93^{a} ±0.05	8.93^{b} ±0.03
Feed conversion efficiency (kg FCM/kg DMI)	0.92 ±0.04	0.99 ±0.05
Average milk CP output (g/animal/ day)	341.9^{a}±1.21	385.1^{b}±1.42
Dietary N secreted into milk	0.24±0.002	0.25±0.003
Cost of ration/kg milk yield (Rs.)	14.31^{c} ±0.46	12.93^{d} ±0.26
Cost of feeding (Rs/day)	144.02±7.51	146.60±5.47
Return through sale of milk (Rs/day)	206.25^{a} ±12.29	253.34^{b} ±11.38

^{a,b}values with different superscripts in a row within respective parameter differ (P<0.01)
^{c,d}values with different superscripts in a row within respective parameter differ (P<0.05)

Table 4. Effect of ration balancing (RB) on different blood parameters

Parameter	Before RB (n=73)	After RB (n=73)
Serum protein (g/dl)	6.02^{a} ±0.12	6.94^{b} ±0.11
Serum albumin (g/dl)	3.17±0.04	3.11±0.05
Serum globulin (g/dl)	2.85^{a} ±0.11	3.82^{b} ±0.11
Serum glucose (mg %)	45.58±1.13	47.07±1.14
Serum triglycerides (mg %)	36.40±1.26	37.97±1.30
Serum creatinine (mg %)	1.23±0.03	1.34±0.03
Serum NEFA (mEq/l)	0.37±0.05	0.39±0.02
Serum IgG (mg/ml)	21.50^{a} ±0.87	23.69^{b}±0.84
Serum IgA (mg/ml)	0.47±0.03	0.55±0.03
Serum IgM (mg/ml)	3.02±0.11	3.30±0.10
Serum IgE (pg/ml)	560^{a} ±21.0	470^{b} ±11.0
Serum FRAP (µM/l)	515.93^{a} ±37.37	1069.29^{a} ±37.87

^{a,b}values with different superscripts in a row within respective parameter differ (P<0.01)

Table 5. Effect of ration balancing (RB) on microbial protein synthesis in cows

Parameter	Before RB (n=73)	After RB (n=73)
Allantoin (mmol/l)	10.81^{c} ±0.38	13.42^{d} ±0.57
Uric acid (mmol/l)	1.18±0.05	1.45±0.10
Creatinine (mmol/l)	6.73±0.30	6.39±0.22
Purine derivatives conc. (mmol/l)	11.99^{a} ±0.39	14.87^{b} ±0.59
PDC index	173.79^{c}±9.51	228.25^{d}±15.84
Total PD excreted (mmol/day)	170.32^{c}±9.32	223.68^{d}±15.52
Absorbed purine (mmol/day)	154.10^{a}±9.34	246.79^{b}±18.18
Intestinal flow of microbial nitrogen (g/day)	112.03^{a} ±6.79	179.42^{b}±13.22
Microbial yield (g CP/day)	700.18^{a} ±42.46	1121.36^{b}±82.62

^{a,b}values with different superscripts in a row within respective parameter differ (P<0.01)
^{c,d}values with different superscripts in a row within respective parameter differ (P<0.05)

Information on effects of feeding balanced rations on solids-not fat, milk production, profitability to farmers, rumen microbial CP synthesis, efficiency of utilization of dietary CP for milk production, feed conversion efficiency and level of plasma immunoglobulins in crossbred cows under field conditions were collected and discussed in this paper.

Data generated from the study indicates that 38% of cows were deficient in energy and protein in the ration, whereas, calcium and phosphorus were deficient in 100% of animals. Kannan and Garg (2009) also reported deficiency of CP, Ca and P under field conditions in the states of Gujarat and Uttar Pradesh.

Thus, even with the available feed resources, there is ample scope to improve productivity of milch animals by way of feeding a balanced ration. Similar findings were also reported by Garg *et al*. (2013). The improvement in milk yield and fat per cent may be due to balancing of nutrients which might have improved microbial protein synthesis and also due to supply of essential minerals. Energy and protein are the most important limiting factors towards milk production and its supplementation in the diets of lactating ruminants increased milk yield significantly. On feeding a balanced ration, dietary energy and protein could be utilized in a more efficient manner in lactating cows. Findings are similar to Haldar and Rai (2003) who reported improvement in milk yield due to supplementation of energy and mineral mixture in lactating ruminants. Another important aspect in the physiology of lactation is the severe drainage of minerals through milk (Garg and Bhanderi, 2011). Supplementation of minerals in the diet of lactating ruminants has been reported to enhance milk production along with an improvement in milk composition (Kannan *et al*., 2010; Garg *et al*., 2016). The results are in agreement with that of Dutta *et al*. (2010) and Khochare *et al*. (2010).

There was significant ($P<0.01$) improvement in SNF content of milk on feeding a balanced ration. This could be due to availability of energy, protein and minerals in appropriate quantity (Bhanderi *et al*., 2016). After balancing feeding, some of the amino acids might go to the depleted thigh muscle and then available for synthesis of milk protein and the SNF content. This could be the probable reason for stabilization of SNF for short period and then again improvement. Optimum levels of protein, energy and minerals are essential for rumen functions and synthesis of milk components in mammary gland. Rumen microbes convert dietary protein into microbial protein, which is a primary source of essential amino acids for the host animals (Bailey *et al.*, 2005). These amino acids are used by the mammary gland to synthesize milk proteins. The relative amounts of protein: energy ratio and minerals that are available in the rumen at a given time is the major factor affecting rumen fermentation and therefore milk components. In addition, rumen microbes contain 13-14% mineral matter (Storm and Orskov, 1983), hence, minerals are very essential component for microbial protein synthesis (Stiffen and Robinson, 1987). Any factors that affect rumen fermentation can change protein levels and thereby, SNF.

Consistently providing balanced and adequate energy, protein and minerals are keys to maintaining optimum levels of milk components. In the present study, energy and protein are either excess or imbalanced and minerals are deficient in the ration of animals. On feeding optimum levels of energy, protein and minerals through mineral mixture might have helped in improving SNF content of milk. These findings are in agreement with (Garg *et al*., 2016). Cost of feeding is the single largest component in the total cost of milk production. In developing countries, where the level of production of cows is not high and the returns from milk production are marginal, this is primarily due to higher consumption of dry matter per litre of milk production. Through balanced feeding it was possible to increase the feed conversion efficiency (FCE) for milk production in cows to produce more milk per kg dry matter. This is useful to increase the profitability of milk producers, and contributes to efficient use of scarce feed resources in developing countries, while achieving targeted milk production (Haldar and Rai, 2003). Shahjalal *et al*. (2000) and Castillo *et al*. (2001) also reported increased FCE for milk production on feeding a balancing diet. Imbalances of nutrients can also alter the activity of certain enzymes, thereby, impairing overall immune function (Spears, 2000). Feeding a balanced ration to animal provides all the nutrients and minerals required for the functionality of numerous structural proteins, enzymes and cellular proteins. In view of this, results of present study indicated that feeding balanced ration to lactating cows help in improving the overall immune status. Minerals are required for the functionality of numerous structural proteins, enzymes and cellular proteins (NRC, 2001; Nocek *et al*., 2006). Supplementation of mineral mixture in the ration of dairy animals could be responsible for greater production of IgG and affecting cell metabolism resulting in better immune status (Wedekind *et al*., 1992). Sub-clinical or marginal deficiencies of minerals may be a larger problem than an acute deficiency (Garg *et al*., 2007; Tomlinson *et al*., 2007) because specific signs of deficiency are not evident, however, the animal continues to grow, produce and reproduce at a reduced rate (Larson, 2005). Reduction in IgE level in blood serum indicates that reduction in allergens in the body might be due to reduction in parasitic infestation.

Microbial protein flow to the duodenum may be regarded as an important and sensitive indicator to optimize rumen metabolism in dairy animals. Level of allantoins in urine is an indicator of microbial protein synthesis in the rumen (Pimp *et al*., 2001; Ramagaonkar *et al*., 2008). Urinary excretion of allantoin has been successfully used to estimate the microbial protein synthesized in the rumen and subsequently digested in the lower gut of ruminants (Dipu *et al*., 2006). Due to imbalanced feeding of nutrients to animals, as practiced in India, the limitation for the growth of microbial cells is probably the inadequate concentration of ruminal ammonia and deficiency of minerals. This leads to change in rumen fermentation pattern towards production of more acetate and butyrate. More acetate and butyrate production leads to production of more hydrogen and carbon dioxide, the main substrate for methane production. Balancing the ration of crossbred cows has resulted significant improvement ($P<0.01$) in purine derivative concentration index, purine derivatives excreted and absorbed purine, thus, significantly improved microbial N supply to cows. Microbial protein synthesis in rumen depends upon supply of ammonia, energy and carbon skeleton for amino acid synthesis (Tomar *et al*., 2010). Most of the carbon skeletons are produced as a result of degradation of carbohydrates into volatile fatty acids. In the present study, the diet was either deficient in CP or energy (Abraham and Gayathri, 2015). In such condition, the inadequate supply of energy or protein might be responsible for poor availability of ATP and carbon skeleton for microbial cell production thereby reducing microbial protein synthesis. After balancing the ration, greater availability of energy or protein might have resulted in increased microbial protein synthesis, thereby, improving the performance of cows. The present findings are similar to Srinivas and Singh (2010) and Ramgaonkar *et al*. (2008) who reported an increased excretion of PD and microbial N supply after supplementing high plane of nutrition in ruminants.

Conclusion

The study demonstrated that feeding a balanced ration not only helped in improving SNF content of milk, but also resulted in improving daily income of smallholder milk producers. Thus, large scale implementation of ration balancing programme can help in improving SNF content of milk and overall profitability from dairying, in various milk-sheds of India.

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