RESEARCH ARTICLE

Impact of balanced feeding on the solids-not-fat (SNF) content of milk

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Abstract: Milk producers across various states face problem of low SNF in milk, resulting into rejections. A study was undertaken to assess the impact of feeding a balanced ration on the SNF content of milk and other performance parameters in crossbred cows and Murrah buffaloes in Ludhiana district of Punjab. Out of 121 animals screened, 40 crossbred cows and 28 buffaloes 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 44% of the animals had excess protein and energy inthe ration, whereas, ration of 63% 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 7.86 to 8.54% in cows and from 8.12 to 9.12% in buffaloes. Average daily milk yield and milk fat increased from 9.35 to 10.36 kg; 4.13 to 4.27% in cows and from 7.54 to 8.25 kg; 6.54 to 7.01% in buffaloes, respectively. This translated into an additional daily monetary benefit of about Rs. 25 and 34 in cows and buffaloes, respectively. Milk production efficiency of fat corrected milk (kg FCM produced/kg DMI consumed) increased from 0.75 to0.89 in cows and from 0.60 to 0.72 in buffaloes, on feeding a balanced ration. Rumen microbial protein (g/d) increased by 42% in cows and buffaloes. Levels of serum immunoglobulins like IgG, IgM and IgA (mg/ml) increased from 21.72 to 28.20, 2.91 to 3.29 and 0.44 to 0.52 in cows, respectively. Similarly, levels of serum IgG, IgM and IgA (mg/ml) increased from 20.89 to 26.43, 2.75 to 3.48 and 0.42 to 0.53 in buffaloes, as compared to animals fed on imbalanced ration. Parasitic load was reduced from 215 to 66and 105 to 35 eggs per gram of faeces, in cows and buffaloes, respectively. 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. 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.

Keywords: Balanced ration, Crossbred cows, Milk production, Murrah buffaloes, Solids-not-fat

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 and 9.0 per cent SNF in cow and buffalo milk, respectively, in most of the states. 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 cow and buffalo's milk. Quality and quantity of milk are determined by the genetics and the feeding practices. Milk urea nitrogen and SNF are correlated (Ayasan et al 2011). Body condition score can affect milk lactose and urea in HF cows (Ayasan et al 2012). No breed improvement programme world over would ever support low SNF content in milk. The possible reason for low SNF in milk in field animals could be on account of deficiency of various critical nutrients (Rook and Line 1961; Annison and McDowell 1977; Garg 2012). 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 this paper.

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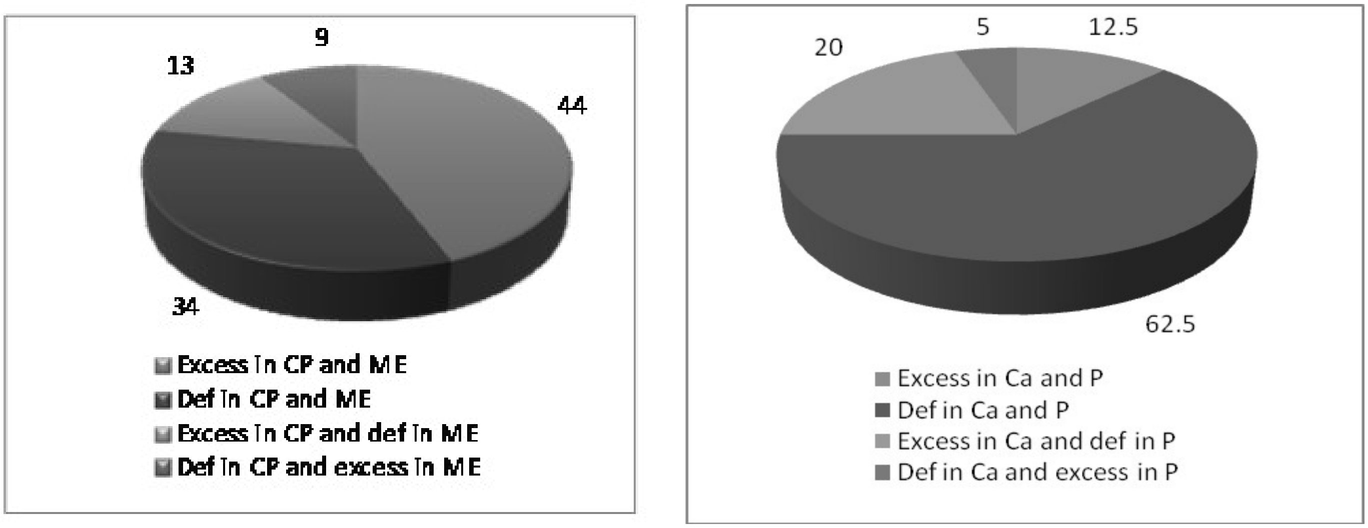

Fig. 1 Nutritional status of lactating cows and buffaloes (%) in the villages of Ludhiana

Materials and Methods

Selection of animals and experimental design:

Out of 121 animals screened, 40 crossbred cows and 28 buffaloes were identified with low SNF from Bhaini Rora and Bopa Rai Khurd villages of Ludhiana district of Punjab. 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, total digestible nutrients (TDN), calcium and phosphorus, using the ration balancing software developed by National Dairy Development Board (NDDB), which is based on NRC (2001) standard for cattle and Kearl (1982) standard for buffaloes. 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, urine and faecal samples were also collected before and after feeding a balanced ration for measurement of different parameters.

Ethical approval for the animals for experimentation:

The guidelines for animal experiments outlined by the Institutional Animal Ethics Committee which approved this study and the ethical guidelines/protocols of the National Dairy Development Board, Anand (Gujarat, India) were followed during all the animal experimentations.

Laboratory analysis:

Feeds and fodder samples were analyzed for proximate composition by AOAC (2005) methods. 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 Antioxidant Power (FRAP) activity (Benzie and Strain 1996) and immunoglobulins (IgG, IgM and IgA), by using kit supplied by DiaSys Diagnostic Systems GmbH (Germany).

Urine (100 ml) samples were collected from individual animals 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 (Chen et al 1990). Purines absorbed and microbial N supply was calculated from the daily urinary purine derivatives excreted (IAEA 1997). Fresh faecal samples were analyzed for parasitic eggs count per gram of faeces. The McMaster technique was used to prepare the faeces for quantification of worm eggs.

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 and Discussion

Feeding practices and nutrient intake by animals:

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

Particular	CB cows (n=40)		Murrah buffaloes (n=28)	
	Before RB	After RB	Before RB	After RB
Body weight (kg)	449.25±7.09	454.68±6.39	494.71±9.36	499.82±10.03
Metabolic body weight (kg $W^{0.75}$)	97.49±1.15	98.39±1.03	104.80±1.51	105.60±1.60
DM intake (kg/day)	12.55±0.34	11.98±0.25	13.18±0.45	12.81±0.32
Concentrate: Roughage ratio	32:68	34:66	33:67	37:63
DM intake (kg/100 kg body weight)	2.81±0.08	2.86±0.06	2.71±0.12	2.60±0.09
CP intake (g/day)	1299±58.24	1235±68.2	1429^{c}±49.6	1382^{d}±46.8
TDN intake (kg/day)	7.12±0.19	6.91±0.21	6.85±0.24	7.18±0.20

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

Table 2 Nutritional status of the lactating cows and buffaloes in the villages of Ludhiana

Nutritional status	No. of animals	Nutritional status	No. of animals
Excess in CP and ME	30	Excess in Ca and P	7
Deficient in CP and ME	23	Deficient in Ca and P	42
Excess in CP and deficient in ME	9	Excess in Ca and deficient in P	17
Deficient in CP and excess in ME	6	Deficient in Ca and excess in P	2

It was observed that mustard and cotton seed cakes were the most commonly used protein source for dairy animals by the farmers in Ludhiana district of Punjab. Farmers also fed crushed maize, rice bran, rice polish, distiller's dried grains with solubles to their animals. Straws of wheat and rice, berseem green, maize fodder and mustard green were used as source of roughages. Analysis of feeding practices revealed that average metabolic body weight and dry matter intake (DMI) were not affected by feeding a balanced ration (Table 1). Nutritional status of the lactating cows and buffaloes in the villages under the study is given in Table 2. It was reported that about 44% of the animals had excess crude protein (CP) and metabolizable energy (ME) intakes compared to their requirements, whereas, calcium (Ca) and phosphorus (P) were deficient in 63% of the animals (Figure 1). Similar findings were also reported by Garg et al (2013).

Effect of feeding a balanced ration on milk yield and fat per cent:

On feeding a nutritionally balanced ration, average daily milk yield and milk fat increased from 9.35 to 10.36 kg; 4.13 to 4.27% in cows and from 7.54 to 8.25 kg; 6.54 to 7.01% in buffaloes, respectively (Table 3). The improvement 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 and buffaloes. 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. 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). The results are in agreement with that of Dutta et al (2010); Kannan et al (2010) and Khochare et al (2010).

Effect of balanced feeding on SNF content of milk:

On feeding a balanced ration for 8 weeks, there was significant improvement in SNF content of milk from 7.86 to 8.54% in cows and from 8.12 to 9.12% in buffaloes (Table 3). It has been 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. 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 per cent mineral matter (Storm and Orskov 1983), hence, minerals are very essential component for

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

Particular	CB cows (n=40)		Murrah buffaloes (n=28)	
	Before RB	After RB	Before RB	After RB
Milk yield (kg/day)	9.35[a] ±0.56	10.36[b] ±0.55	7.54[a] ±0.37	8.25[b] ±0.36
Milk fat (%)	4.13±0.10	4.27±0.05	6.54[a] ±0.19	7.01[b] ±0.13
FCM (kg/day)	9.43[a] ±0.53	10.73[b] ±0.56	7.97[a] ±0.42	9.20[b] ±0.42
SNF (%)	7.86[a] ±0.06	8.54[b] ±0.03	8.12[a] ±0.062	9.12[b] ±0.052
Feed conversion efficiency (kg FCM/kg DMI)	0.75[a] ±0.04	0.89 [b] ±0.05	0.60[a] ±0.03	0.72[b] ±0.03
Average milk CP output (g/animal/ day)	308.5[a]±1.44	341.90[b]±1.12	263.9[a]±1.78	288.7[b]±1.45
Dietary N secreted into milk	0.24[a]±0.002	0.28[b]±0.003	0.18[a]±0.001	0.21[b]±0.004
Cost of ration/kg milk yield (Rs.)	13.99[c] ±0.64	12.64[d] ±0.30	17.58±0.97	17.05±0.59

[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 ofration balancing on blood parameters and parasitic load in cows and buffaloes

Particular	CB cows (n=40)		Murrah buffaloes (n=28)	
	Before RB	After RB	Before RB	After RB
Serum protein (mg%)	6.60±0.09	6.66±0.12	6.38[c] ±0.12	6.78[d] ±0.09
Serum albumin (mg%)	3.03±0.08	2.94±0.06	2.98±0.09	2.97±0.07
Serum globulin (mg%)	3.57±0.11	3.72±0.14	3.39±0.16	3.81±0.10
Serum glucose (mg%)	43.01±2.94	45.10±1.35	44.04±2.24	47.61±1.80
Serum triglycerides mg%)	43.01±0.76	44.50±1.39	42.89±0.75	44.18±1.56
Serum creatinine (mg%)	1.17±0.07	1.38±0.05	1.12±0.09	1.32±0.04
Serum NEFA (mEq/l)	0.32[a] ±0.02	0.23[b] ±0.01	0.43[c] ±0.04	0.31[d] ±0.01
Serum IgG (mg/ml)	21.72[a] ±1.10	28.20[b] ±1.06	20.89[a] ±1.12	26.43[b] ±0.70
Serum IgA (mg/ml)	0.44±0.05	0.52±0.03	0.42±0.06	0.53±0.04
Serum IgM (mg/ml)	2.91[c] ±0.13	3.29[d] ±0.15	2.75[a] ±0.19	3.48[b] ±0.14
Serum FRAP (µM/l)	496.37[a] ±47.46	929.77[b] ±30.63	463.75[a] ±51.41	985.04[b] ±34.35
Faecal eggs per gram (EPG)	215.00[a] ±43.49	66.00[b] ±20.83	105.00[a] ±22.91	35.00[b] ±10.67

[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)

microbial protein synthesis (Sniffen 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. s availability to host animals.

Balanced feeding and 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 of cows (n=40) before and after feeding a balance ration was 0.75 and 0.89, respectively and in buffaloes (n=28) the values were 0.60 and 0.72. Efficiency of utilization of dietary protein for milk production also improved significantly (P<0.01) after feeding a balanced ration (Table 3) in cows and buffaloes.

There was also reduction in feeding cost from Rs. 13.99 to 12.64 per kg of milk yield in cows and from Rs. 17.58 to 17.05 per kg of milk yield in buffaloes. On an average, there was increase in daily milk yield (kg/animal) and fat (%) by1.01; 0.14 in cows and 0.71; 0.47 in buffaloes, respectively. This translated into a

Table 5 Effect of ration balancing on microbial protein synthesis in cows and buffaloes

Particular	CB cows (n=40)		Murrah buffaloes (n=28)	
	Before RB	After RB	Before RB	After RB
Allantoin (mmol/l)	11.19[c] ±0.45	14.07[d] ±0.63	10.34[a] ±0.46	12.37[b] ±0.34
Uric acid (mmol/l)	1.26±0.06	1.45±0.11	1.15[c] ±0.07	1.41[d] ±0.12
Creatinine (mmol/l)	6.93±0.35	6.28±0.26	7.11±0.38	6.10±0.30
Purine derivatives conc. (mmol/l)	12.45[a] ±0.46	15.52[b] ±0.65	11.49[a] ±0.46	13.79[b] ±0.37
PDC index	176.30[c] ±11.03	248.93[d] ±23.96	174.48[a] ±13.71	246.24[b]±19.29
Total PD excreted (mmol/d)	172.78[c] ±10.81	243.95[d] ±23.48	170.99[a] ±13.43	241.32[b]±18.90
Absorbed purine (mmol/d)	156.56[a] ±10.87	270.64[b] ±27.53	153.19[a] ±13.34	265.88[b]±22.00
Intestinal flow of microbial nitrogen (g/d)	113.82[a] ±7.90	196.75[b] ±20.01	111.37[a] ±9.70	193.29[b]±15.99
Microbial yield (g CP/d)	711.35[a] ±49.37	1229.70[b] ±125.0	696.06[a] ±60.62	1208.08[b]±99.97

[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)

daily monetary benefit of about Rs. 25 and 34 in cows and buffaloes, respectively.

Effect of balanced feeding on different blood parameters:

Levels of serum immunoglobulins like IgG, IgM and IgA (mg/ml) increased from 21.72 to 28.20, 2.91 to 3.29 and 0.44 to 0.52 in cows, respectively. Similarly, levels of serum IgG, IgM and IgA (mg/ml) increased from 20.89 to 26.43, 2.75 to 3.48 and 0.42 to 0.53 in buffaloes, as compared to animals fed on imbalanced ration (Table 4). 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 and buffaloes helped 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). Subclinical 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). There was no significant change in protein, glucose and creatinine levels in blood, on feeding a balanced ration.

Balanced feeding and faecal egg counts:

By feeding a balanced ration, average eggs per gram of faeces reduced from 215 to 66 in cows and from 105 to 35 in buffaloes(Table 4).

Increase availability of essential nutrients can be expected to improve host resistance to gastro-intestinal nematodes provided that they are first limiting to immune functions (Houdijk 2012). Animals fed on imbalanced diet are vulnerable to parasitic infestation due to lower host immunity reaction (Athanasiadou et al 2009). Parasitic load in dairy animals affect growth, milk production (Fekete and Kellems 2007) and general health as these parasites hijack vital essential nutrients supplemented through feed and feed supplements. Balanced feeding is an excellent way to reduce and eventually eliminate parasites by enhancing overall vitality of the body. Better nutrition has been shown to reduce parasitic load through improvement in immunity of animals (Hoste et al 2005; Houdijk 2012).

Balanced feeding and microbial protein synthesis:

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 (Ramgaokar et al 2008; Pimp et al 2001). 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). Microbial N yield (g CP/day) increased significantly (P<0.01) from 711 to 1229 in cows and from 696 to 1208 in buffaloes, after feeding a balanced ration (Table 5).

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 animals. 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 ration had excess of CP and TDN and deficient in minerals. In such conditions, the imbalance or inadequate supply of energy, protein and minerals 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 nutrients might have resulted in increased microbial protein synthesis thereby improving the performance of cows and buffaloes. 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.

Conclusions

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.

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