Reduction in metabolic disorders in dairy cattle on feeding a balanced ration

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Abstract

Metabolic disorders can invariably be prevented by ensuring the best possible dietary balance of critical nutrients and particularly careful management of cattle at drying off, during the dry period and in early lactation. Calcium metabolism of close-up dry and fresh cattle is critical for reducing incidence of metabolic disorders. Anionic salts fed to the close-up group can reduce the incidence of milk fever, displaced abomasum, and sub-clinical hypo-calcemia in early postpartum dairy cattle. Negative energy balance, fat mobilization and subsequent elevations in ketone body concentrations play a contributing role in the expression of fatty liver syndrome, clinical ketosis, and abomasal displacement. A negative energy balance may also increase the risk of retained placenta, metritis, and mastitis through impaired immune function. High grain diets may lead to more incidence of rumen acidosis. These disorders could be prevented or minimized by feeding a balanced ration. Balanced feeding also helps in improving milk production efficiency, microbial protein synthesis, antibody titres in vaccinated animals, immune status, reproduction efficiency, net daily income of milk producers and reducing parasitic load and enteric methane emission from dairy animals. Large-scale implementation of ration balancing programme with the available feed resources helps in reducing metabolic and reproductive disorders in dairy animals in developing countries.

Key words: Metabolic disorders, balanced ration, milk production efficiency

Introduction

Dairy cattle requires balanced diet for optimal productivity and to maintain normal health (Garg, 2012). During peak production the output exceeds input, the animals meet out their normal requirements by mobilization from its body reserves for a shorter period. But continuous imbalances develop into productivity related problems. High yielding dairy animals are more susceptible to metabolic and reproductive disorders during the peri-parturient period (Goff *et al*., 1991). Minimizing post-calving disorders is crucial for making a smooth transition from dry and transition phases to productive lactations with high peak milk levels. Prevention of post-calving metabolic disorders begins with sound dry and transition cow management practices, which include providing a clean, dry calving area and minimizing post-calving stress along with balanced ration incorporated with critical nutrients (Horst *et al*., 1997). Some of the aspects of productivity losses in dairy animals due metabolic and reproductive disorders and benefits through feeding a balanced ration are discussed in this paper.

Reduction in metabolic and reproductive disorders

Sub-Acute Ruminal Acidosis (SARA) is a disorder of ruminal fermentation, characterized by extended periods of ruminal pH below 5.5-5.6 (Al Jassim and Rowe, 1999). For optimum ruminal fermentation and fibre digestion, ruminal pH should lie between 6.0 and 6.4 (Krause and Oetzel, 2006). Incorrect diets or feeding can lead to overly-rapid fermentation in the rumen, reducing the pH below the level at which the microbes are most active (Krehbiel *et al*., 1995; Maekawa *et al*., 2002). This slows down forage digestion and reduces both feed intake and cud chewing which makes the problem worse by limiting the buffering effect of salivation (Beauchemin, 1991). Low milk fat percentages are a common symptom of acidosis which, in severe cases, causes cows to go off their feed completely and milk yields to drop (Penner et al., 2006). Ruminal pH in normal physiological range was maintained by supplementing buffer as sodium bi-carbonate ($NaHCO_3$): magnesium oxide (MgO) in 3:1 ratio (Garg, 2012). This led to increase in milk fat and solids-not-fat (SNF) content of milk (Table 1)

Table1. Effect of feeding a balanced ration along with buffers 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	8.10^{a} ±0.06	9.12^{b} ±0.05
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)				

Milk fever: The huge demand for calcium produced by the onset of milk production can cause blood calcium levels to drop sharply, precipitating milk fever either before or at calving (Oetzel, 1991). Even though cows can mobilize skeletal calcium, the process is slow and made worse by the demands of high yielding animals. After calving, parathyroid gland is unable to mobilize sufficient Ca to meet the high requirements, leading to maximum risk of milk fever in dairy animals (Garg and Bhanderi, 2013). Dietary cation anion difference (DCAD) of -10 to -15 meq/100 g DM is effective in preventing milk fever.

Dairy cattle diets with a high DCAD (alkaline diets) tend to cause milk fever, while a low or negative DCAD (acidic diets) tends to prevent milk fever. Acidic diets promote bone mobilization (osteocytic resorption) since bone (along with the kidney) acts as a buffer against excessive systemic acidity (Horst *et al*., 1997). Acidic diets have minimal effect on intestinal absorption of calcium. Additionally, low DCAD diets have been shown to increase the amount of 1,25 di-hydroxyvitamin D produced per unit increase in parathyroid hormone. This increases osteoclastic bone resorption, which is probably the most important calciotropic effect of acidic diets. In our study, about 150 animals were supplemented with anionic salts prior to calving, resulted into lower blood pH, which activated hormones responsible for Ca homeostasis. Urine pH and blood serum calcium (Ca), phosphorus (P) and magnesium (Mg) were monitored during the trial period.

Monitoring urinary pH after feeding an acidifying diet is the most direct and useful approach to establishing the optimal DCAD (Davidson *et al*., 1995). Mean urinary pH values in a group of pre-fresh dry cows should be between about 5.5 and 6.5 if anions are correctly dosed and the diet is properly formulated and delivered. Blood serum calcium, phosphorus & magnesium levels were 6.8 to 8.6, 3.2 to 5.5 and 2.5 to 3.5 mg/dl, respectively and no signs of milk fever were observed in supplemented animals. A change in urine pH on feeding anionic salts is depicted in Figure 1.

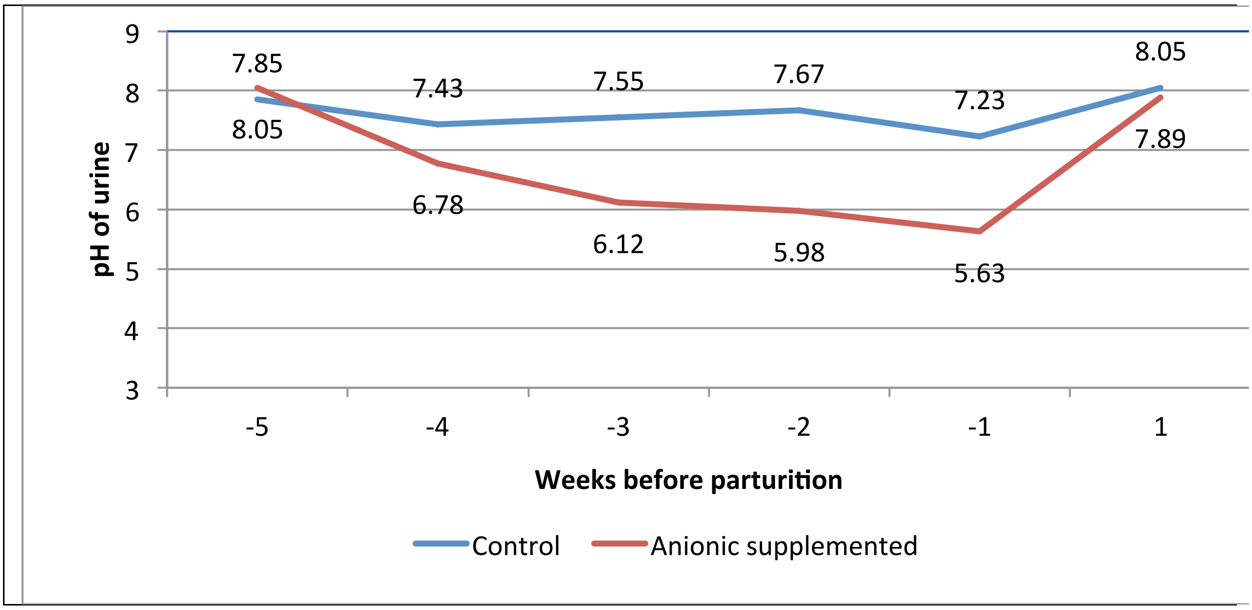

Fig. 1: Effect of feeding anionic salts on urine pH of dairy cattle

Ketosis is a metabolic disorder, which occurs predominantly during early lactation and typically is secondary to other problems, such as retained placenta, metritis, fat cow syndrome, mastitis, or displaced abomasum. These conditions can compromise dry matter intake, resulting in excessive body fat mobilization. As body fat mobilization accelerates after calving, the liver often becomes overloaded with fatty acids, resulting in excretion of ketone bodies. This incomplete metabolism of fats is manifested as ketosis.The main cause of ketosis is the under-feeding of energy; poor quality forage or a shortage of silage in the winter being major underlying factors. When a group of cows is considered to be at particular risk, individuals may be drenched with 0.5 litres of propylene glycol at calving to provide an immediate sugar source that reduces fat mobilisation in the liver. Feeding 1kg/day of ground maize can have a similar effect since it resists rumen breakdown and is absorbed directly as glucose.

Mastitis is inflammation of the udder, most costly disease affecting dairy animals throughout the world (Singh and Singh, 1994). However, sub-clinical mastitis (SCM) is 30-40% higher than clinical mastitis (CM), which can be prevented through proper hygiene and by feeding a feed supplement 4 weeks prior to calving. A feed supplement was formulated and fed daily @ 10 g per head to 230 crossbred cows for 4 weeks prior to calving, with a history of CM and SCM in the previous lactation. On feeding the supplement, incidences of SCM in these cows post calving reduced by 80%, as confirmed by the *Mastect* and *California Mastitis Test* (Table 2). Out of 177 supplemented cows, only 36 (20%) showed signs of SCM with *Mastect* strip and CMT, which was confirmed by SCC in milk (average 7.26×10^5 cells/mL milk). However, 67 animals (86%) out of 78 in control group were affected by SCM which was also reflected in higher SCC compared to the supplemented group (average 10.11×10^5 cells/ml milk), which was later aggravated to CM. Milk pH, EC, Na and Cl content in milk were higher (*P<0.05*) in animals affected by SCM than the normal animals. In experimental group, SCC in 141 animals was within the normal range ($1.22\text{-}2.36 \times 10^5$ cells/mL milk) and no signs of SCM were observed. Milk lactose, protein content and FRAP activity were higher in normal as compared to affected animals (Bhanderi *et al*., 2015).

Table 2. Effect of feeding antioxidant supplement on different parameters in crossbred cows

Particulars	Control animals (n=78)		Supplemented animals (n=177)	
	Normal (n=11)	SCM Affected (n=67)	Normal (n=141)	SCM Affected (n=36)
Incidence (%)	14	86	80	20
Milk pH	$6.52^{a}\pm0.01$	$6.99^{b}\pm0.04$	$6.50^{a}\pm0.02$	$6.86^{b}\pm0.05$
Electrical conductivity (mS/cm)	$4.56^{c}\pm0.16$	$6.78^{d}\pm0.12$	$4.03^{c}\pm0.07$	$6.24^{d}\pm0.06$
Somatic Cell Counts ($\times10^5$/mL milk)	$2.01^{c}\pm0.06$	$10.11^{d}\pm0.32$	$1.51^{c}\pm0.28$	$7.26^{d}\pm0.51$
FRAP (µM/L)	$1126^{a}\pm10.71$	$454^{b}\pm14.31$	$1329^{a}\pm35.88$	$451^{b}\pm17.42$
Na (mg/dL)	$57.68^{a}\pm1.63$	$126.90^{b}\pm2.48$	$57.18^{a}\pm0.82$	$118.66^{b}\pm1.66$
Cl (mg/dL)	$137.79^{a}\pm1.05$	$176.22^{b}\pm4.93$	$122.85^{a}\pm3.64$	$163.55^{b}\pm3.20$
K (mg/dL)	$137.06^{a}\pm1.46$	$117.50^{b}\pm0.84$	$136.03^{a}\pm0.75$	$122.04^{b}\pm2.39$
Protein (%)	3.71±0.03	3.60±0.03	3.70±0.01	3.63±0.05
Lactose (%)	$4.67^{a}\pm0.09$	$4.11^{b}\pm0.03$	$4.47^{a}\pm0.09$	$3.94^{b}\pm0.05$

$^{a,\,b}$ Values with different superscript in a row within respective parameter differ at $P < 0.05$
$^{c,\,d}$ Values with different superscript in a row within respective parameter differ at $P < 0.01$

Reproductive disorders: Since large number of animals in the developing countries suffers from reproductive disorders on account of minerals deficiency, ration should be supplemented with good quality mineral mixture for improving reproduction efficiency. Poor nutritional status is also the major constraints in the productive life span of bovine. Incidence of anoestrus and repeat breeding conditions are widely reported in India and other developing countries (Garg *et al*., 2008). Looking to the great importance, effect of glycine based chelated trace minerals (copper, zinc, manganese, chromium) on reproduction efficiency in anoestrus / repeat breeding animals (n=44) was studied. Out of 44, 36 animals conceived on feeding a supplement for 60 days. The supplement was found to be effective in 82% animals for curing anoestrous and repeat breeding conditions. The study indicates that glycine based trace mineral chelates are effective in improving reproduction efficiency in animals suffering from anoestrus and repeat breeding conditions. Effect of feeding a balanced ration on different performance parameters is as follows:

Effect on milk production, milk fat & daily feeding cost: Animals (n=1.5 million) fed on a balanced ration showed improved daily milk production by 0.2-1.5 kg and milk fat by 0.1 to 0.7 per cent unit (Garg *et al*., 2013). There was reduction in daily feeding cost by Rs. 0.95 to 2.50 per kg of milk. This led to increase in net average daily profitability per animal by Rs. 25-30, in animal yielding 6-8 kg of milk.

Effect on milk production efficiency: Milk production efficiency (kg Fat Corrected Milk yield/kg dry matter intake) increased from 0.58 to 0.78 in cows and from 0.53 to 0.66 in buffaloes.

Effect on solids-not-fat (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 (n=70) and from 8.12 to 9.12% in buffaloes (n=28). There was significant improvement in milk production, rumen microbial protein synthesis, immune status and reduction in parasitic load.

Effect on antibody titres in FMD vaccinated animals: Higher antibody titres are associated with greater resistance to disease. The immune response against FMD was estimated in vaccinated animals fed on traditional and balanced rations. On feeding a balanced ration, antibody titres were significantly higher in vaccinated animals (n=70) fed on a balanced ration as compared to vaccinated animals fed on traditional ration (Table 3).

Table 3. Effect of balanced ration on antibody titre against FMD vaccinated animals

Sero-type	Antibody titre against FMD (SN_{50} value)	
	FMD vaccinated animals fed on traditional ration	FMD vaccinated animals fed on balanced ration
FMD type-O	1.80^{a} ±0.11	2.31^{b} ±0.09
FMD type-A	1.62^{a} ±0.13	2.14^{b} ±0.10
FMD type Asia-1	1.99^{a} ±0.14	2.62^{b} ±0.21
a,b means with different superscript in a row differ significantly (P<0.05)		

Effect on microbial protein synthesis: Rumen microbial nitrogen (N) yield (g CP/day) increased significantly (P<0.05) by 39 and 44% in cows and buffaloes, respectively after feeding a balanced ration. Similarly, efficiency of microbial protein synthesis increased significantly (P<0.05) by 36 and 38% in cows and buffaloes, respectively after feeding a balanced ration.

Effect on immune status: On feeding a balanced ration, the levels of serum immunoglobulin, such as IgG, IgA and IgM increased from 22.36 to 28.45, 0.76 to 0.96 and 2.56 to 3.14 mg/ml, respectively. The study indicated that balanced feeding helps in improving immune status of dairy animals (Table 4).

Table 4. Effect of balanced feeding on immune status of animals

Immunoglobulins	Control (n=30)	Experimental group (n=40)
Serum IgG (mg/ml)	22.36^{a} ±1.08	28.45^{b} ±0.95
Serum IgA(mg/ml)	0.76±0.08	0.96±0.07
Serum IgM(mg/ml)	2.56^{a} ±0.18	3.14^{b} ±0.11
FRAP (µM/l)	678.45^{a}±38.76	1095.08^{b}±60.72
a,b means with different superscript in a row differ significantly (P<0.05)		

Effect on methane emission: Methane is the major green house gas emitted during enteric fermentation in dairy animals and is responsible for global warming. Cows (n=80) and buffaloes (n=82) were selected from different agro climatic regions of the country. Baseline methane emissions of each animal were estimated by using SF_6 tracer technique, thereafter the ration was balanced as per their nutrient requirements. After 30 days of feeding balanced ration, methane emission by animals was estimated again (Garg *et al*., 2013). Balancing of ration significantly (P<0.05) improved milk yield by 5-10% and milk fat by 4.0-6.5% in both the species (Table 5). On feeding a balanced ration, methane emission reduced (P<0.01) by 15-20 per cent per kg of milk, in cows and buffaloes.

Table 5. Effect of feeding a balanced ration on enteric methane emission reduction

Species		MY (kg/d)	Fat (%)	CH_4 emission (g/kg MY)	Reduction (%)
Western region					
Cows (*n*=30)	Before RB	11.9[a]	4.1	19.3[a]	15.5
	After RB	12.4[b]	4.3	16.3[b]	
Buffaloes (*n*=22)	Before RB	8.5	6.5[a]	27.3[a]	17.9
	After RB	8.9	6.8[b]	22.4[b]	
Northern region					
Cows (*n*=20)	Before RB	6.5[a]	4.2	32.8[c]	19.8
	After RB	7.2[b]	4.3	26.3[d]	
Buffaloes (*n*=34)	Before RB	6.5[a]	6.5[a]	36.9[a]	17.6
	After RB	7.0[b]	7.0[b]	30.4[b]	
Southern region					
Cows (*n*=30)	Before RB	8.4	4.1	22.2[a]	15.3
	After RB	8.8	4.1	18.8[b]	
Central region					
Buffaloes (*n*=26)	Before RB	6.1[a]	6.5[a]	25.3[c]	19.4
	After RB	6.6[b]	6.8[b]	20.4[d]	

[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)

Effect on parasitic load: During the trial period, the intensity of infection as faecal egg counts ranged from 80 to 280 and 20 to 120 per gram of faeces in control and experimental groups, respectively. By feeding a balanced ration to animals, average eggs per gram of faeces reduced from 168 to 81. An increased availability of essential nutrients can be expected to improve host resistant to gastrointestinal parasites provided that they are first limiting for immune functions (Houdijk, 2012). Animals fed on imbalanced diet are vulnerable to parasitic infestation due to lower host immunity reaction. Parasitic load in dairy animals affect growth, milk production and general health as these parasites hijack vital essential nutrients in the assimilation form supplemented through feed and feed supplements (Fekete and Kellems, 2007). Supplementing essential nutrients in adequate amount is an excellent way to reduce parasites by enhancing overall vitality of the body.

Summary

Results of different studies under field conditions indicate that feeding a balanced ration not only helps in improving milk production efficiency, immune status and net daily income of milk producers but also in helps in reducing metabolic disorders and enteric methane emission in dairy cattle in the developing countries. Large scale implementation of ration balancing programme can help in improving productivity of dairy animals with the available feed resources, in environmental friendly manners.

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