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NUTRITIONAL STRATEGIES FOR MAXIMIZING BUFFALO PRODUCTION EFFICIENCY

Estrategias nutricionales para maximizar la eficiencia de la producción de búfalos

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INTRODUCTION

Since more than 5000 years ago, buffalo have played a significant role in Asian livestock farming, providing milk, meat, skins, and draught power. Buffaloes, described as the ''Black Gold'', are the favourite multipurpose animals of farmers and are, in fact, the ''bank on hooves'' with massive potential for social and economic changes for the agrarian community. Asia is home to more than 90% of the world's buffalo population, with 77.9% living in South Asian nations. The 20th livestock census between 2012 and 2019 shows that the buffalo population increased by 1.06%. India is the greatest producer and exporter of buffalo meat and the country with the highest population of buffaloes in the world (57% of the total). The leading states in buffalo rearing are Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Andhra Pradesh, Maharashtra, Haryana, Telangana, and Punjab. In these states, raising buffaloes generates between 54-85% of the nation's milk production, a significant income source for rural households.

According to predictions made by Opio et al. [31], the demand for animal products is likely to rise further by 70% by 2050 due to industrialization and rising population, both of which may put significant strain on the planet's natural resources. Because there is increased demand for limited resources nowadays, it is necessary to increase the efficiency of dairy animals, making improvements in feeding management a crucial strategy. Generally, it is a well-known statistic that feeding accounts for around 70% of the ongoing costs associated with starting a dairy operation. Currently, the farming community is one of many involved in feeding management. The purpose of feeding management is also evolving as time goes on. Also, with the increasing livestock population and farming sectors, ruminants are blamed for global greenhouse gas production. Animal production makes for around 37% of the world's CH_4 emissions and 14.5% of the world's anthropogenic greenhouse gas emissions within the agricultural sector [31].

OPTIMUM FEEDING PRACTISES TO INCREASE PRODUCTION PERFORMANCE

Feeding frequency

It may be possible to better understand the underlying processes of dry matter intake by tracking circadian (virtually 24-h) feed intake trends. More recently, increasing feeding frequency from once to twice or twice to four times daily increased average feeding time per cow in group-fed lactating cows [10]. Over the course of the 24-hour period, the cows fed more often consumed their food more evenly. Additionally, the more frequent feeding resulted in less feed sorting. This might increase fiber digestibility, which the frequent feeding may have decreased.

Improving the availability of feed and fodder and advising on ration balancing

The genetic potential of animals could be harnessed by providing balanced nutrition and keeping them healthy. Animals of high genetic potential are maintained with high-quality feeds, which include fodder crops/silage, grains, and protein concentrates, often in the form of a total mixed ration. Like many affluent nations, livestock nutrition in India often consists of one or two concentrate feed components that are locally accessible, grasses, and forages, which might result in imbalanced feeding owing to either too high or too low amounts of energy and protein. Because the milk production capacity of dairy animals is only partially used, imbalanced feeding harms the health and productivity of animals in numerous ways. It also lowers the net daily revenue to milk producers from dairying. The Ration Balancing Programme was established to inform farmers about the effects of unbalanced feeding and the significance of providing animals with a balanced diet. With benefits for both farmers and the environment, "ration balancing" has been put into place in 18 states under the National Dairy Plan-I, a project supported by the World Bank and the government of India.

The NDDB created this innovative initiative to balance the ratio of animals being picked up using simple software that can be used by committed and knowledgeable local resource personnel assigned to the area. By visiting milk producers and registering their animals in the NDDB's animal identification system, local village resource people who have been educated in animal nutrition are employed by this scheme. The local village resource people then create the optimized rations using the ration balancing software based on body weight, milk output, and milk fat yield.

Garg et al. [14] studied the effect of ration balancing on twenty-six lactating buffaloes. They reported that the average increase in milk yield, fat (%), 6% FCM yield (kg/day), and microbial nitrogen supply in lactating buffaloes were higher (p<0.01) than before the implementation of the program. Similarly, methane emission in terms of g/kg DM intake, g/kg OM intake, and g/kg milk yield were also reduced (p<0.01). The gross energy lost as methane was reduced (@ 18.13%; p<0.01) in buffaloes after balancing the ration. The ration balancing program has reduced the cost of feed per liter of milk for cows in Gujarat and Punjab by roughly 18–19% and for buffaloes in Gujarat by about 2.6%, according to field-level statistics by Sirohi et al. [40]. Tomar et al. [41] conducted a field survey to assess the ration balancing program undertaken by ICAR-NDRI on the extent of productivity increase and cost reduction on the adoption of balanced animal ration. Results revealed that the average daily milk yield of Murrah, HF, and Jersey crossbreds was significantly increased by 25.7%, 18.8%, and 37%, respectively. Fat% and SNF% were improved significantly (p<0.01) only in Murrah buffaloes fed with a balanced ration. However, the feed cost per kg of milk of the RBP animals was around 15%, statistically significant (p< 0.01) lower than the non-RBP animals.

BENEFITS OF RBP

1. An increase in milk output that contains more fat and fat-free solids
2. Increased fertility efficiency
3. Reduction in the inter-calving period, thereby increasing the productive life of animals
4. A decrease in the emissions of methane.
5. Farmers in various parts of the nation who provide balanced animal rations have seen a rise in their net daily revenue of between Rs.15-25 per animal.

UREA MOLASSES BLOCKS

Although the major base feed for buffaloes is cellulosic material, seasonal shortages sometimes happen during weather extremes, droughts, and flood conditions, negatively impacting the buffalo output. Solid blocks containing a mix of urea, molasses, and minerals have been created and fed to buffaloes. These blocks are chosen over ammoniating crop leftovers as a source of fermentable carbohydrates and nitrogen because they are simple to export and secure for usage by farmers. Urea molasses block supplementation to buffaloes enhanced growth and milk production when given with straw-based diets [35].

PRECISION NUTRITION

Providing an animal with feed that satisfies its nutritional needs for maximum production efficiency to create better-quality animal products is referred to as precision feeding. It is a tool for effectively utilizing available feed resources to maximize the animal's response to nutrients for economic production. Precision nutrition aims to precisely meet the nutritional needs of livestock, increase production efficiency, reduce environmental pollution, improve nutrient utilization, lower feeding costs, decrease feed refusal by livestock, reduce nutrient excretion in feces and urine, lower labor costs, and increase overall profit.

Tools to achieve precision animal nutrition

Processing methods for food: It consists of methods like grinding and pelleting. The feed should be ground to a homogeneous particle size of 600 µm since this enhances nutrient uptake. Enhancing digestibility, improving feed conversion efficiency, and accelerating calf growth are all made possible by particle size reduction. According to one study, feeding pellets reduced feed waste by up to 5% and decreased DM excretion by 23%, N excretion by 22%, and feed efficiency by 6.6%.

Strategic nutrient supplementation: Some nutrients, particularly mineral combination and vitamin premix, are needed in extremely small doses. However, their inclusion in the diet is necessary for optimal production. Specific nutrient supplementation (e.g., AA, iodine, lipids, vitamins, minerals) has altered important performance variables, including lactation, reproduction, offspring survival, and growth at crucial developmental time windows. However, occasionally, the diet may include enough levels of nutrients, but the animal may have a deficiency condition and be unable to use them effectively. This might be caused by: a) The animal not having the enzyme necessary to break down the meal and use that specific nutrient, such as lignified cellulose or phytic phosphorus, b) Antagonistic interaction of nutrients among themselves, e.g., Copper – Zinc mineral interaction (bioavailability decreases) c) Parasitic infestation also decreases voluntary feed intake, absorption of nutrients, e.g., stomach worms, liver flukes, and intestinal parasites.

Precise ration formulation

Many nutritionists suggested that developing a low-cost, adequate feed is key to the dairy industry's profitability. Concerns about the unjustified use of hormones and antibiotics in food animals to increase output and their harmful effects on consumers owing to their residues have been raised in recent years. Therefore, a modern animal nutritionist must provide diets devoid of antibiotics, hormones, meat and bone meals, and other unpleasant feed components, which harm both animal and human health and result in significant financial loss. Even though it might be difficult for animal nutritionists to develop feeds that generate animal products that consumers would accept, do not cause environmental pollution, preserve animal health, and stay commercially viable. Ration must be balanced and palatable for the animals.

METABOLIC AND FERMENTATION MODIFIERS

In general, substances given, injected, or implanted into animals are called metabolic modifiers. These compounds enhance nutrient utilization, feed efficiency, growth rate, milk supply, and composition. Products called fermentation modifiers are added to feed to control rumen fermentation and improve feed utilization. Conjugated linoleic acid, chromium, carnitine, magnesium, niacin, manganese, selenium betaine, and vitamins A, D, and E are among the metabolic and fermentation modifiers widely used in dairy and beef processing. Other fermentation modifiers include methane inhibitors, proteolysis and deamination inhibitors, defaunation agents, microbial enzymes, buffer agents, ionophores, yeast cultures, and mold. Animals given bST injections had an average milk output of 25% higher than control animals. No adverse effects of bST injection on the buffaloes' reproductive response were documented by Usmani and Athar [46]. The amount of feed consumed and milk produced by buffaloes getting bST injection was noticeably higher than in controls. Niacin is produced in ruminants by rumen microbes, and its production has been deemed sufficient for ruminant performance. Niacin addition in buffalo diets increased rumen fermentation by lowering ammonia-N concentration and raising protein synthesis [23].

NUTRITIONAL MANAGEMENT OF BUFFALO CALVES

An effective calf-feeding method is essential for having good dairy replacement stock since it influences the enterprise's future profitability and sustainability. The buffalo husbandry and research area that has received the least attention is buffalo calf nutrition and feeding management. According to Wynn et al. [52], inadequate colostrum and calves' improper feeding practices contributed to increased mortality and morbidity losses in buffalo calves. Although calves in South Asia are often taken away from their mothers at birth, they are permitted to drink a small amount of milk for a few weeks directly from the dam's teat at each milking. The calves are then typically milk-weaned between the ages of 4 and 12 weeks. The cost of milk, the dam's behavior when the calf is being weaned off of milk, and the calf's gender are the primary factors in buffalo calf milk weaning. Therefore, it is crucial to create and employ appropriate scientific language based on the physiology, body mass, and age of buffalo calves in the first place. Then, for calves raised for two different goals, namely milk and meat production, considerable coordinated research efforts are needed to design pre-weaning and post-weaning nutritional regimens and feeding management systems.

PROBIOTICS

The concept of direct-fed microbials is different from the term probiotics. Probiotics are live beneficial bacteria that, when administered in adequate amounts, confer a health benefit on the host [19], often by colonizing the gastrointestinal tract and supporting the native microflora that is already established in the animal's digestive system. The DFM has a narrower definition than probiotics as it is defined as a source of life, naturally occurring microorganisms alive, that improve the digestive function of livestock. The emergence and manifestation of antibiotic resistance in the food chain have prompted a search for alternatives to antibiotics that have growth-promoting effects on livestock. Since the diversity of the rumen microbiome is closely related to the animal's ability to acquire and assimilate nutrients, ideal growth promoters would have only a negligible impact on the animal's natural microbiome while enhancing the animal's growth, well-being and reproduction [8, 29].

Numerous studies on animals have demonstrated the benefits of probiotics in terms of feed efficiency [28], growth performance [42], nitrogen retention [36], and decreased risk of intestinal infections [38]. When symbiotic formulation was given as a supplement to Murrah buffalo calves, improved digestibility, average daily gain, and lower incidence of diarrhea and fecal scores were seen. Similar outcomes were noted when *Limosilactobacillus reuteri* BF-E7 and *Ligilactobacillus salivarius* BF-17 were given to Murrah buffalo calves [47, 48]. Previous research [1, 5, 25] has found similar increases in growth performance, demonstrating the benefits of probiotics, notably LAB, for preruminant calves. Other studies found contradictory results, such as no appreciable differences in DMI, ADG, or nutritional digestibility when feeding LAB to calves [53, 22]. The variation in results might be related to the host's age, health, management, nutritional state, type, or changed probiotic effect with different doses, feeding schedules, bacterial strains, or other factors [51]. Feeding probiotics, prebiotics, and synbiotics to Murrah buffalo calves significantly enhanced structural development and performance, according to recent experiments conducted in our lab [37, 39].

NUTRITIONAL STRATEGIES IN REDUCING ENTERIC METHANE PRODUCTION

The ruminal microbiome is extraordinarily diverse, with bacteria (10^{10}-10^{11} cfu/mL, >200 species), protozoans (10^4–10^6 cfu/mL, 25 genera), fungi (10^3–10^5 cfu/mL, 6 genera), and methanogens (10^6 cfu/mL) making up the majority of its constituents.

A group of microorganisms known as methanogens are found in the Archaea domain, with certain cyanobacteria and marine microbes also contributing in trace amounts [26]. In 2020, cattle and dairy cows were the main sources of CH_4 emissions, making for 72% of all sector emissions [12]. According to Opio et al. (2013), 8.7% of CH_4 emissions are caused by buffalos. Methane has a lifespan of 12.4 years in the atmosphere and is 84 times more powerful on a 20-year timeline than carbon dioxide (CO_2) in terms of potential for global warming [32]. Additionally, ruminants lose up to 12% of their total energy intake due to methane generation [43]. In order to reduce CH_4 emissions from animals, especially ruminants, breeders and researchers from all over the world have been concentrating on both raising animal output and doing so. Culling nonproductive and low-producing animals in wealthy nations is advised to lower CH_4 emissions. Due to economic, cultural, and religious differences in emerging nations, this is both impracticable and challenging. Various farming techniques, dietary changes, feed additives, chemical methanogenesis modulators, probiotics, vaccination against the rumen microbiota, selective breeding, and genetic methods are now employed to minimize CH_4 emissions in ruminants. These tactics heavily rely on the direct and indirect suppression of methanogens by feed additives [9, 17]. Between 1960 and 2018, the literature contained about 9000 studies on rumen methanogenesis [7].

Leitanthem et al. [24] observed a reduction in CH_4 (%) and CH_4 (mL/100 mg dDM) with increased supplementation of *Moringa olifera* leaves (0%, 5%, 10%, 15%, 20%, 30%, and 40%) in *in vitro*. Gupta et al. [18] reported that daily enteric methane production was reduced by 12.61% numerically when sodium monensin (0.6 mg/Kg body wt) was fed to Murrah buffalo heifers. Dixit et al. [11] found that CH_4 emissions decreased from 34.48 to 12.73 g/Kg DMI when murrah buffalo calves were fed graded levels of dietary crude protein (5, 7.5, 10, 12.5 and 15%). Feeding practices like precision feeding and changing grazing management practices can decrease CH_4 emissions [6, 49]. Medium-chain fatty acids found in coconut oil and palm kernel oil have been shown to suppress methanogenesis by poisoning protozoa. According to Zhang et al. [54], methanogens may reduce the amount of dissolved hydrogen in the rumen by hydrogenating unsaturated fatty acids in corn oil. Because medium-chain fatty acids are poisonous to methanogens and protozoa, they can stop the processes that produce CH_4. A moderate dietary lipid percentage of less than 6% can reduce 24-hour CH_4 emissions by up to 20% with enhanced feed efficiency, according to Beauchemin et al. [7]. Similar to this, ionophores like monensin reduce CH_4 emissions by inhibiting the action of bacteria that break down cellulose. Ionophores have the ability to reduce the population of gram-positive bacteria such cocci bacteria, which effectively inhibits the formation of acetate and CH_4 [3]. The impact of probiotics on CH_4 mitigation has also been gradually reported by several researchers [33, 50] by adding several probiotics like *Ruminococcus flavefaciens, Propionibacterium* and *Lactobacillus rhamnosus* and *Enterococcus* into diets of sheep. A final dose of $6*10^{10}$ cfu/animal/day of *Lactobacillus pentosus* D31 results in a decrease of methane of around 13% [20]. Similar to this, methanogen cell lysis had been accomplished by carbon nanoparticle application [13].

DEVELOPMENT OF RUMINANT DERIVED FUNCTIONAL FOODS

As animal-derived foods are the major contributors of saturated fatty acids (SFA) and trans fatty acids due to biohydrogenation, people are increasingly skeptical about the adverse health effects of consuming dairy-origin foods. In the long run, a high intake of SFA has been associated with increased blood-low-density lipoprotein cholesterol, leading to atherosclerosis and other cardiovascular-related diseases [16]. Most food regulatory bodies recommend that total SFA consumption should not exceed 10-11% of total daily energy intake [45]. Nutritionists are relentlessly working on dietary strategies to reduce SFA levels in animal-derived food through rumen manipulation techniques. Such initiatives have increased conjugated linoleic acid (CLA) and other polyunsaturated fatty acids (PUFAs) in milk and its byproducts.

The fatty acid metabolism can be modulated either by increasing the fatty acids source/ content in the feed or by restricting the biohydrogenation process in the rumen. Research on the modulation of milk FA composition has developed specific nutritional strategies based on these two points. These strategies rely, in particular, on feeding pasture [44], supplementing vegetable oils [21], oilseeds, fish oils [30], and addition of phytoadditive or plant secondary metabolites in the ruminant diet. Banakar et al. [4] reported increased concentrations of PUFA such as vaccenic acid, linoleic acid and decreased concentration of saturated fatty acids when *Aloe vera* extract (2 and 4% of DMI) was fed to cross-breed (Alpine × Beetal) lactating goats. Alipanahi et al. [2] found higher milk vaccenic acid (trans-11 C18:1) and CLA (cis-9, trans-11 C18:2) concentrations in goats fed the oak acorn (9.1 g/Kg DM tannins) with or without polyethylene glycol supplementation compared to control group. Miri et al. [27] reported that dietary supplementation of (*Cuminum cyminum*) seed extract in goats increased the ruminal concentration of CLA by 34.8% and VA by 11.4% in the lower supplemented group as compared to CSE free diet. Rana et al. [34] reported that the concentration of stearic acid was decreased whereas rumenic acid and CLA were increased in the *Longissimus dorsi* muscle of young goats treated with *Terminalia chebula* compared to the control. Gesteira et al. [15] noticed a drop in the oleic acid and MUFA levels in the salted and sun-dried meat from young Nellore bulls treated with condensed tannin extract (0, 10, 30, or 50 g/kg of dry matter) from *Acacia mearnsii*.

CONCLUSION

Ruminant cattle do not directly compete with the human population because they can create high-quality human food, especially high-quality protein, from feedstuffs that have little or no value for human food. By offsetting maintenance and other nutritional expenses, strategies that boost output per animal are an excellent way to improve the sustainability of ruminant production. Dairy output is greatly enhanced by feeding practices such as ration balancing, precision nutrition, and methane mitigation techniques. Probiotics are fed to dairy calves at a very young age to aid in better colonization, increased performance, decreased mortality, and calf scours. The challenge for scientists in many developing countries is how best to combine in a diet for dairy animals the available green forage, crop residues, and agro-industrial by-products with the available protein resources and molasses/urea block to increase the performance of buffaloes. Think of your buffalo as a family for maximum productivity and success. You will be rewarded with lots of nourishing milk if you take the time to attend to all of their needs.

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