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Review Article

Nutraceuticals in Ruminant Feeding

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Abstract

The notable accountabilities of the diverse and complex microbial communities of ruminant animals apropos of several physiological functions like digestion, nutrient utilization, immunity system, etc. is remarkable. However, scientists do work on development of more optimum production and better feed efficiency ratio by means of modulation and alteration of this microbial population in ruminants. Nutraceuticals have highly achievable impact on Ruminant health and improvement on production. Various studies have shown the advantages of using Nutraceuticals in Ruminants for gut health and proved impact on production. Through this article an attempt has been made to enunciate the benefits of nutraceuticals in ruminant feeding system.

Keywords: Digestion; Modulation; Microbial Population; Nutraceuticals; Ruminants

Introduction

The advancements in the Nutritional Science over the years is highly remarkable. Constant efforts of the Researchers have made it possible in the development of newer techniques considering traits like production of high quality feed at low and affordable cost of production for the benefit of farmers. Feeding in case of Ruminants mainly comprises of Concentrates and roughages. Further, the shrinkage in availability of grassland, pasture land could not make it to get solidify for the requirement of high yielders. Again, the climate change is also one of the executable reasons. The booming demand for more production of animal products has compelled the scientists to relocate new strategies in terms of nutrition primarily, although management, breeding policies, etc. are also matter of concern. Nutraceuticals have magnificent application in prevalence of Ruminant feeding. Ruminants harbour the microbial population in its rumen, mostly help in digestion compiling the complexity level high. In the animal production system, inclination towards the intestinal health is increasing [36]. However, the ban on use of Antibiotics, hormones in animal rearing system, nutraceuticals could be an alternative approach. Nutraceuticals put a positive impact on the digestive tract ecosystem of animals, primarily by inhibiting pathogenic microbial growth [45]. Nutraceuticals can be the choice of hours for optimum production and sustainability in terms of profitability to be achieved by while Ruminant farming is an option. Therefore, this review article aims to evaluate about what is Nutraceuticals, utility of Nutraceuticals, future scope of using Nutraceuticals in ruminant feeding.

Basic concepts of nutraceuticals

The term "nutraceutical" is a combination of two words i.e. "Nutrition" and "Pharmaceutical". It is firstly termed by Stephen DeFelice in 1989. DeFelice defined nutraceutical as, "a food (or part of a food) that provides medical or health benefits, including the prevention and/or treatment of a dis-ease". Das., *et al.* 2012 defined

"nutraceutical" as any food or food particles that play an essential role in maintaining normal body function that provides health benefits, including the prevention and treatment of a disease [8]. Nutraceuticals can be classified as follows - According to Pandey., *et al.* 2010 [30]; Riva., *et al.* 2017 [37] nuteaceuticals classified as a) Potential Nutraceuticals and b) Established Nutraceuticals. Again Gupta., *et al.* 2010 [13] classified nutraceuticals into three categories viz., i) Nutrients (includes - minerals, fatty acids, amino acids, vitamins) ii) Herbs and iii) Dietary supplements. Kalia (2005) [18] classified nutraceuticals into 7 classes- i) Dietary fiber ii) Probiotics iii) Prebiotics iv) Polyunsaturated fatty acids v) Antioxidant vi) Polyphenols vii) Spices. The types of feed, feed additives and/or nutraceuticals used to feed the animal would directly or indirectly create consequences on production like meat, milk, egg, wool, etc. The versatile range of benefits in nutraceuticals in ruminant feeding confers its wide uses among the farmers. The modulation of gut microbial ecosystem due to application of probiotics lead to improvement of gut enzyme activity and stabilization of ruminal Volatile Fatty acids (VFAs) proceed to reduction of ruminal acidosis condition [12].

Probiotics utility in ruminants

Probiotic means "for life". The term was coined by Parker in 1974. He defined it as "organisms and substances which contribute to intestinal microbial balance." FAO/ WHO has defined "Probiotics" as "Live microorganisms, which, when administered in adequate amounts, confer a health benefit on the host" [10]. Probiotics are also referred as direct-fed microbial (DFM). The Gastro intestinal tract of ruminants (cattle, buffalo, goat, sheep) are already a reservoir of several thousands of microbiota. Upto 90% of the total community of the gastro intestinal bacterial groups in cattle had already been identified [48,49]. The primarily habituated microbial groups in the rumen includes *Lactobacillus, Selenomonas*, *Prevotella*, *Streptococcus*, and *Megasphaera,* and fiber-degrading bacteria such as *Ruminococcus*, *Butyrivibrio, Fibrobacter*, and *Bacteroides* [25]. Although many of the gut microbiota are yet to be identified. The main function of these microbial population is to help in digestion and fermentation. So, care should be taken in choosing microbial strains such that they do not hamper the indigenous gut microbiota population of the host. The potentiality of probiotic strain could be rationalized if they have the ability to adapt the gut environment and have the capability to pinpoint itself to a befitting slot in the rumen and incur positive effects on the host [50]. [9,26,39] had reported increment in feed intake, immunity system, milk production and most important one is gut health improvement due to usage of Probiotics. In ruminants, administration of probiotics is usually practiced by oral means [2,52] and imparts beneficial effect in utilization of nutrients, prevention of pathogenic microbes and other health benefits. To be effective, probiotics must able to produce antimicrobial property towards pathogens [23]. They should have adherence ability with the epithelium and colonization and must impose positive effect on the host animals [39].

Items	Description
Competitive exclusion	Compete for nutrients in the gastro-intestinal Exclusion property towards pathogens
Antimicrobial effects	Produce antimicrobial substances which have bacteriostatic or bactericidal properties Reduce luminal pH and Inhibits the growth of bacteria (G-negative) by producing hydrogen peroxide
Immune booster	Stabilize intestinal integrity and improve the gut innate immune response through chloride secretion or increasing mucus production
Antitoxin effects	Inhibits toxin expression in pathogenic bacteria Neutralize pathogens by producing enterotoxins
Effect on nutrient digestibility	Increase digestive enzyme activity in the gastrointestinal tract Increase the digestion and absorption of nutrients
Ant-oxidative activity	Stress mitigation ability

Table 1: Mode of action of probiotics [43].

In neonatal calves, the count of *Lactobacillus* and *Bifidobacteria* are less, and supplementation of the same showed growth improvement [24]. Application of probiotics increases the production of natural cytokines, lymphocytes, macrophage, immunoglobulin (IgG, IgM and IgA) and killer cells which trigger stimulation of both humoral and cell mediated immune system [5,6,11,21,39,54]. According to Yirga, immunomodulation activity shown by probiotics are may be due to these reasons: i) They can either penetrate through the intestinal wall as well as cells or can multiply ii) the released antigens from the dead organisms stimulate the immune system. Therefore, thus they induce the immune responses [53]. Several studies had been performed by scientists from different corner to concede the adequacy of probiotics in ruminant feeding. Rigobelo., *et al.* 2014 [35], studied that sheep contaminated with a non-O157 Shiga toxin-producing *Escherichia coli* (a foodborne pathogen of humans) infection had reduced the fecal shedding of the pathogen after administration of probiotic mixture contain-

ing *Lactobacillus lactis*, *Lactobacillus bulgaricus*, *Lactobacillus acidophilus*, *Lactobacillus helveticus*, *Streptococcus thermophilus and Enterococcus faecium*. In case of sheep, probiotic feeding has several appreciable positive impact on Nitrogen utilization, methanogenesis, energy retention, etc. Particularly, by addition of yeast culture and β1–4 galacto-oligosaccharides in sheep diet, methane emission can be decreased [27].

Probiotic strains	Species	Consequences	References
Bacillus species or LAB species	Young calf	Balance the gut microbial ecosystem and reduce the adhesion of pathogen	[55]
LAB species (*Lactobacilli* and *Enterococci*)	Cattle	stabilize the rumen pH	[16]
Megasphaera elsdenii and *Selenomonas ruminantium* sub spp	Cattle	Stabilize the rumen pH, rumen microbiota, improve the immune action and enhance-plant cell walls degradation in the rumen	[17]

Table 2: Examples of some of the probiotic strains along with their consequences.

Buffalo calves had improved dry matter intake, better feed conversion efficiency, and apparent digestibility of nutrients than the control group [44] after feeding *Lactobacillus acidophilus* mixed feed. The mammary gland condition and strengthening of the functions of the teat sphincter can be improved by *Lactobacillus* base teat spray [3]. Cows showed enhanced milk production by 2.3 L per cow each day after supplementing with 5×10^9 CFU of *Enterococcus faecium* and 2×10^9 CFU *Saccharomyces cerevisiae* cells [28]. Supplementation of probiotic had portrayed appreciable effect on reducing ruminal acidosis in feedlot cattle and dairy cows, and showed potential response in improving immune system in calves succumbing to stress condition [22] and also enhanced food intake, ameliorated feed efficiency, and boosted up average daily gain, more milk yield and high quality [32, 46]. The applicability of probiotics may induce to improve animal health, increased productivity [15] and improved immunity of the host [31].

Effect of prebiotics on ruminant health

The Term Prebiotics coined by Gibson and Roberfroid (1995). They defined it as "Non digestible food ingredients that beneficially affect the host by selectively stimulating the growth and or activity of one or a limited number of bacteria in the colon" Commonly used prebiotics are oligosaccharides including inulin, mannanoligosaccharides (MOS), fructooligosaccharides (FOS), xylo-oligosaccharides, galactooligosaccharides, soya-oligxosaccharides, pyrodextrins, and lactulose. Prebiotics contribute immensely in enhancing host performance and energy utilization. Number of rumen bacteria can ferment prebiotics into short chain fatty acids like acetate and butyrate as energy source at large intestine of the host [42]. Samanta., *et al.* 2007 [41] had pointed out some of the criteria for a compound to be recognized as a prebiotic-

- They should be indigestible by the animal's own gastric or pancreatic enzymes.
- The gut microflora should able to utilize them selectively (exception several rumen bacteria ferments prebiotics).
- They could be originated from plant or be produced by microbial enzymes.
- There should be non-absorption in respect of the epithelial surface in digestive tract.
- Structural and functional integrity should be protected by them during passing through either acidic or alkaline pH condition in the alimentary tract.
- Even at minute concentration, they should have the ability to exhibit its potentiality.
- During any physio-chemical processes *i.e.* grinding, chewing, deglutition, mixing with fluids like saliva, etc. they should remain intact.
- The chemical bonds present in them should be obscured to the damaging microbiota.
- There should not be any residual problems in livestock or their products.
- They should be non-carcinogenic.
- The fermentation process should not produce any toxic metabolite.
- There should not be any hurdle in mixing with other feed compounds or micronutrient mixture.

Several studies had been performed on feeding prebiotics to ruminants for recognizing the effect of prebiotics. It was reported that as growth substrate, hemicellulolytic bacteria can employ xylooligosaccharides [7]. Feeding milk replacer with inclusion of inulin to the pre-ruminant calves reported increased live weight gains

and improved feces consistency [19,51]. As a result of prebiotic administration to sheep, suppression of ammonia producing bacteria happened which attributed for reduction of rumen ammonia nitrogen concentration [27].

The incidence of occurring enteric diseases and also severity of the same could be reduced by supplementing Fructooligosaccharides (FOS) and Bovine serum (Spray dried) in combination to the calves [34]. The enzymatic treatment of whey with beta-galactosidase produces Galactosyl-lactose (GL), a trisaccharide (galactose plus lactose). Feeding Galactosyl-lactose in combination with milk replacer to dairy calves reported positive effects attributed to growth and betterment in health [33]. The diversive benefits of prebiotics application include modulation of gut microbiota, exclusion of pathogen, absorption of mineral, etc. [38,40].

Effect of organic acids on ruminant health

Organic acids are common components of plants as well as animal tissues. The examples are acetate, butyrate, lactate, fumaric, propionate, tannic, caprylic acids, etc. Carboxylic acid is the familiar organic acid mainly, commonly found in biological tissues. Supplementation of organic acids to dairy cows could be useful in enrichment of exertion of dietary nutrients in alimentary canal [1]. They can help in decreasing the metabolites which are toxic in Nature, the changes in the endocrine system in cow body during stress like severe heat condition. Organic acid supplementation could create an impact on betterment of protein bioavailability and improved in Calcium, Magnesium, Phosphorus and Zink uptake [14,47]. Amjed., *et al.* 2013 [4] had studied the effect of supplementing organic acids in terms of feed intake, milk yield and milk composition in dairy cows during heat stress condition. He reported that supplementing organic acids could improve animal health and the production losses could be diminished and overall profitability of the farms could be upgraded. Dietary inclusion with organic acids may trigger to decreased duodenal pH, increased N retention and improved nutrient digestibility [20,29].

Conclusion

The continuous growth of human population demands more production of animal products. The need for the hour is to get some promising elucidation such that without hampering the health and well beingness of the animal the productivity gets increased. After ban of antibiotic on animal use, applicability of nutraceuticals could be a good option. Farmers can implement the use of nutraceuticals on their livestock as a feed supplementation after consulting an experienced vet. The benefit of using nutraceuticals on animal health and production is vivid and also immense. The application of nutraceuticals could be a boon to farmers.

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