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Effect of Various Feed Additives on Calves Rumen Ecology : A Review

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Abstract

Use of feed additives is one of the best methods to reduce the feed cost which improve feed efficiency and daily gain. Besides, the feed additives have secondary benefits; include reduction in the incidence of acidosis, coccidiosis and grain bloat. The most feed additives used to enhance the performance can be grouped as antibiotics, ionophores, sulfonamides, probiotics, herbal drugs, microbial culture, saponins and essential oils, mineral mixture and vitamins including coccidiostats. Each feed additives has its own characteriatics feature and feeding limitation, that is, use of high level of feed additives can be toxic and decrease the animal performance. Monensin as a feed additives reduced total VFA and ruminal protozoans. Similarly virginiamycin and avoparcin inhibit the bacterial growth with an increase physical growth in wethers. Sulfonamide, cocciodiostat probiotic, hebal drugs, mineral mixture and vitamins were used as feed additives which reduced the pathogen population and improved digestibility and growth performance of calves. The aforesaid antibiotics, Ionophores, sulfonamides, probiotics and coccidiostats can be used as feed additives in animal rations, which will not only reduce the pathogen population found in GIT tract but also will improve the performance of the animals.
Key words : Feed additives, VFA, Pathogens, Growth performance.

Ruminants have the ability to utilize fibrous non-protein nitrogenous feed and capable to convert the low quality feeds into high quality protein because of microbial fermentation which convert plant carbohydrate and nitrogenous compounds into volatile fatty acids and microbial biomass that serve as sources of energy and protein. Ruminant livestock has been recognized as major contributor to green house gases. Enteric methane emissions represent an economic loss to the farmer where feed is converted to CH_4 rather than to product output. Mosdern feeding practices are geared toward high production of milk and meat, and have presented some novel challenges to rumen microflora. The microbial response to these challenges has not always been satisfactory to the producer, leading to speculation on how the rumen fermentation might be "improved" to enhance both production and animal welfare. There are several methods to reduce methane emission from the rumen. These methods include processing of feeds, altering the types of ration, supplementation of unsaturated fatty acids, defaunation, organic acids, halogenated methane analogues, ionophores, microbial feed additives, non-ionic surfactants, sulfates and herbal products. Herbal preparations have been used for centuries for various purposes because of their antimicrobial properties and because most of them are categorized under GRAS (generally recognized as safe) for human consumption. The use of herbal preparations appears as one of the most natural alternative to the antibiotic use in animal nutrition.

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Feed Additives

One of the best methods to reduce feed costs is through the use of feed additives. Their primary effects are to improve feed efficiency but they may have an equal effect on daily gain. Some feed additives have secondary benefits which include reducing the incidences of acidosis, coccidiosis, and grain bloat, while others suppress estrus, reduce liver abscesses, or control foot rot problems.

In general, most feed additives used for performance enhancement can be divided into five main categories : Antibiotics; ionophores; sulfonamides; coccidiostats; probiotics; herbal drugs; microbial culture; saponins and essential oils; mineral mixture; and vitamins. Each feed additive has its own characteristics and feeding limitations. Some are approved to be fed in combination with others. Using the proper level of feed additives is important because too high a level can be toxic and/or decrease animal performance.

Antibiotics in Calves Feeding Systems

A substance, suh as penicillin or streptomycin, produced by or derived from certain fungi, bacteria, and other organisms, that can destroy or inhibit the growth of other microorganisms. Antibiotics are widely used in the prevention and treatment of infectious diseases.

Kumazawa et al. (1) reported that depriving the course of screening few new antibiotics enhancing rumen fermentation; a novel peptide antiniotic (aibellin) was found in the fermentation broth of the fungus, *Verticimonoporium ellipticus* D1528. Efficiency enhancing effects of aibellin on rumen fermentation with goats (16—18 kg) were investigated and compared with ionophore antibioticas feed additives found reduction in total VFA, widely used as a feed additive for ruminants. Aibellin, at 80 mg day, ehhanced propionate production without significant effect on the production of total VFA or protozoal numbers. Monensin, at 20 mg day, caused increase in propionate production, but decrease in total VFA and protozoal numbers. Aibellin should thus serve as a modifier of rumen fermentation. Further Marounek et al. (2) in a biological test found the stability of virginiamycin and avoparcin in the rumen fluid. Two rumen-fistulated wethers were fed on virginiamycin (100 mg/head daily) for 2 months. Rumen fluid was diluted with buffer and incubated anaerobically at 39 degrees C. Virginiamycin and glucose were added at 10 and 10 g/liter, respectively. The broth was inoculated with *Bacillus stearothermophilus* 794B and incubated overnight at 60 C. This procedure was also used to test the stability of avoparcin in the rumen. Cell-free incubation fluid with virginiamycin had no effect on growth of the indicator organism when added to the MRS broth at 0.25%, but prevented growth at 0.50%. Cell-free incubation fluid containing avoparcin inhibited growth of *B. stearothermophilus* in a dose-dependent manner. No effect on growth was found at 0.20%. Full inhibition of growth was observed at 2% addition. Lastly concluded that both feed antibiotics are stable in the rumen fluid of adapted wethers.

Ionophores in Calves Feeding Systems

Ionophores are a unique class of antibiotics that selectively affect certain microorganisms by altering the passage of ions through "pores" on their outer cell membrane, thus the name "ionophores" were originally used as a coccidiostat in the poultry industry. Later, they were shown to enhance feed efficiency in cattle by altering the microbial fermentation of feed in the rumen. In this regard (3) conducted a study on two rumen-fistulated, non-lactating Holstein cows fed on chopped timothy hay 12 times daily and assigned to one of four dietary treatments; control (no additives), monensin 350 mg, lasalocid 350 mg and maize oil 500 g daily. When cows were fed on monensin, the ratio of rumen acetate to propionate decreased from 4.2 to 2.9, and the K_d of monensin was 8-fold greater than the value for mixed rumen bacteria from control cattle. Monensin supplementation also caused a 2-fold increase in the K_d of lasalocid. Although daily lasalocid supplementation had no effect on the rumen acetate to propionate ratio, it caused a 2-fold increase in the K_d values of monensin and lasalocid. Increases in K_d occurred almost immediately after ionophore addition to the ration, and the K_d values returned to their prefeeding values within 14 days of withdrawal. Ionophore supplementation had no effect on K_{max} values, and approximately 50% of the population was always highly ionophore-resistant. Because K_d values of even adapted rumen bacteria were low (<1.5 micro M). It appears that a large proportion of the rumen ionophore is bound non-selectively to feed particles or ionophore-resistant bacteria.

Omar (4) reported that twelve 380 kg beef steers fed a 90% concentrate, cracked corn-based diet at 85% of ad libitum; steers were divided into three daily ionophore treatment groups, Monensin-Tylan (MT), Lasalosid (L) or rotation of MT and L (MTL). A conventional digestibility trial was conducted with nine steers (three per treatment) at day 34 of feeding the ionophore and lasted for six days. Digestible energy (83.7%), urinary losses (3.3%) of total feed energy and the ratio of ME/DE (90%) did not differ across treatments. Methane losses were from 17 to 37% less on day 2 and 5 for MT and MTL treatments but increased quadratically (P<0.05) on day 16 and 45 so that production exceeded to 0 levels. Treatment L did not affect methane production. Acetate to propionate and to butyrate ratios were reduced (P<0.05) by MT and MTL with no effect for L addition.

Sulfonamides in Calves Feeding Systems

The sulfa-related group of antibiotics, which are used to treat bacterial infection and some fungal infections. Sulfa drugs kill bacteria and fungi by interfering with cell metabolism. They were the wonder drugs before penicillin and are still used today. Because sulfa drugs concentrate in the urine before being excreted, treating urinary tract infections is one of their most common uses. In the said context (5) studied that sulphamethoxazole was injected i.v. into 3 calves at 15 mg/kg, and two cows at 10 mg/kg. The sulphonamide was eliminated rapidly by glomerular filtration; while the metabolite was excreted by renal tubular secretion.

Shoaf et al. (6) in a study found the Holstein male calves given orally and subcutaneously (SC) at thirty milligrams per kilogram of sulfadiazine/trimethoprim (SDZ/TMP, trib-rissen) to two. One group fed with milk-replacer throughout the 13-week period of the study while the second group weaned into a chopped grain-fiber mixture. Trimethoprim bioavailability, following oral administration at 1, 6 and 12 weeks of age, is higher in milk-fed calves (non-ruminants) than in grain-fiber-fed calves (ruminants); bioavailability decreases with increasing age in both groups of calves. Absorption of SDZ is rate-limiting and determines the biological half-life of the drug; SDZ serum concentrations above 2 (μg/ml were maintained in all calves for at least 24 h. Following s.c. administration of tribrissen to 7-and 13-week-old calves, urinary excretion patterns indicated that TMP was slowly released from the injection site; serum concentrations were below 0.1 μg/ml. In contrast, absorption of SDZ was rapid; values for t_{max} were 1.5—1.8 h.

Coccidiostats in Calves Feeding Systems

A chemical agent added to animal feed (as for poultry) that serves to retard the life cycle or reduce the population of pathogenic coccidia to the point that disease is minimized and the host develops immunity. As a result of the legislative changes in 1986, some coccidiostats earlier approved as feed additives are today instead authorized for use as medicated feed.

Chandrawathani et al. (7) found that the effects of helminthiasis on the growth rate of 75 indigenous beef cattle (Kedah-Kelantan breed) in Malaysia were studied. The calves were narurally infected; faecal examination showed the presence of the helminths *Strongyloides papillosus, Haemonchus, Moniezia* and *Toxocara,* and the protozoa *Eimeria bovis, E. zuernii* and *E. ellipsoidalis*. Twenty-five calves were treated orally with 4.5 mg/kg oxfendazole every 20 days from birth to 6 months and then every 30 days until they were 12 months old. Another 25 were treated subcutaneously with 220 micro g/kg ivermectin every 40 days from birth to 6 months and then every 60 days until they were 12 months old. A third group of 25 served as untreated controls. All groups were given an oral coccidiostat (23 mg/kg sulfatriad) every 10 days for the first 3 months and thereafter as considered necessary to control *Eimeria*. From 8 to 12 months of age, calves treated with ivermectin and oxfendazole had significantly higher daily weight gains (0.28 and 0.25 kg/day, respectively) than untreated calves. Calves treated with ivermectin and oxfendazole also gave higher returns (RM49 and RM24 per calf, respectively) than untreated animals.

Sivula et al. (8) conducted a study on various dairy farm to see the influence of managemental practices on the occurrence of enteritis, pneumonia or death between birth and 16 weeks of age on various dairy farms situated in southeast Minnesota. The feeding of a coccidiostat to pre-weaned calves increased the herd risk of pneumonia and feeding of a vitamin A-D-E supplement to pre-weaned calves exerted a protective effect against scours.

Probiotics in Calves Feeding Systems

A probiotic (*P*) is defined as a live microbial feed supplement that improves the intestinal microbial balance of the host animal. The term probiotic describes viable microbial cultures, culture extracts, enzyme preparations, or various combinations of these. In 1908, Metchnikoff first proposed that consuming *Lactobacillus* species was desirable and prevented diseases caused by enteropathogens. The antibiotics destroyed naturally occurring intestinal bacteria, resulting in diarrhea. Studies involving the effects of probiotics on health and performance of ruminants have only occurred recently. Probiotics protecting young animals against enteropathic disorders and increasing feed conversion efficiency and weight gain in growing animals. It appears that for a probiotic have symbiotic relationship between the host and probiotic in terms of gastrointestinal tract environment of the host animal, conditions for growth, reproduction, or lyses of the probiotic, target of action, and the effectiveness of the probiotic. This symbiosis is particularly important in functioning ruminants where the effects of P are thought to be mainly mediated by their effects on the rumen microbes. Certain probiotics have beneficial effects in rumen, including the prevention of rumen acidosis. A reduced risk of acidosis in cannulated dairy cows in early lactation fed with lactate-producing bacteria (*Lactobacillus* and *Enterococcus*) once daily for 21 days in situ was found. These bacteria caused the rumen microflora to adapt to the presence of lactate within the rumen. In another experiment (9) calves fed with probiotic (*Enterococcus faecium* M74) have reduced fecal count of clostridia and enterococci and weighed more at 20, 40 and 62 days of age by 4.9 and 9.75% ($P<0.05$) and by 9.4% ($P<0.01$), respectively, than the control calves.

Herbal Drugs in Calves Feeding Systems

Herbal medicine, sometimes referred to as botanical medicine or herbalism, involves the use of plants, or parts of plants, to treat injuries or illnesses. This field also covers the use of herbs or botanicals to improve overall health and wellness. Herbalist, herbal medicine practitioners, traditional medicine practitioners, and Ayurvedic, homeopathic, and naturopathic healers all use herbal remedies in their practices. Herbal medicines, just like all veterinary medicines, are licensed by the Veterinary Medicines Directorate (the agency of MAFF which deals with animal medicines).

Shukla et al. (10) made a study of lactic acidosis was induced in 16 calves by feeding with wheat flour after a 24 h fast. Groups of four animals were treated after 48 h with sodium bicarbonate at 650 mg/kg body weight orally, three times at 6 h intervals, followed by rumen fluid fresh (group 2); or preserved for 48 h (group 3) at 15 ml/kg intraruminally and repeated after 18 h; or with fresh rumen fluid and an oral bolus of ruchmax or pachoplus (herbal therapeutic agents, group 4); group 1 (controls) was left untreated. The efficacy of the treatments was assessed by recovery from clinical effects, and physiological changes in samples of rumen fluid and blood collected from the animals before and 36 h after induction of lactic acidosis, and 12, 24, 48 h and 5 days after treatment. Recovery (restoration of ruminal pH and protozoal motility) was most rapid in the group given rumen fluid and the herbal preparations. Yadav et al. (11) observed the effect of herbal drug on pH, WA and microbial population a mixture of herbal drug was given to two groups of calves along with one control group. The herbal drug was composed of some herbs like chirayita, kutki, cordimom, guruchi, kalmegh, bhumyamalki, neemchhal, annis seed, cumin or ajwain, black pepper, piplamul, ghee-kunvar, azmoda, yeast along with ammonium chloride and certain other minerals. Nine healthy cross-bred calves were selected; divided into three groups with three calves in each group. The period of each trail was of three months including one month of pre-experimental feeding. The experimental trails were conducted in switch over design. Results showed positive effect of compounded herbal drug on pH, VFAs (acetic acid, propionic, butane acid and other VFAs) and microbial population (protozoal number and types). The high level of drug (D_3=80 g) improved the rumen ecosystem (pH, VFA and protozoal population) compared to control group (D_1=without drug) and low dose of drug (D_2=40 g). This herbal drug had no adverse effects on animal body.

Bhatt et al. (12) examined that the effect of feeding two herbal preparations (ruchamax and payapro) on the milk yield and rumen parameters in lactating crossbred cows. The animals in group I were not given any supplement and acted as control. The animals in second and third groups were given either ruchamax at 30 g per day or payapro at 4 tablets per day, respectively for 15 consecutive days in a month for 3 months, commencing 3 days after calving in addition to the usual feed/fodders and were termed as ruchamax supplemented and payapro supplemented animals. Significant ($P<0.05$) differences were observed in milk yield and rumen parameters of cows fed herbal preparations as comparad to control. The ammonia nitrogen was highest (22.8 mg 100 m/liter) in control animals, whereas total volatile fatty acids and bacterial and protozoal counts were highest in ruchamax supplemented, moderate in payapro supplemented and lowest in control animals, respectively.

Microbial Culture in Calves Feeding Systems

In the dairy industry, these products were first used in cow rations to increase dry matter intake during the transition period or periods of strees. Cellulolytic bacteria in the rumen are stimulate by YC. Fiber digestion in calves and cows is improved by adding YC to the diet. Yeast also provides growth factors, such as malate and vitamins. The most common YC used in ruminant diest is *Saccharomyces cerevisiae. Aspergillus oryzae* is a fungal DFM, but is commonly classified under yeast DFM. Misra (13) found that simple indigestion was experimentally induced in five cow calves on 1.5 years of age. Gram-negative rods, cocci and cocco-bacillary organisms were predominant in the rumen fluid of normal calves and gram-positive organisms in the rumen fluid of calves with simple indigestion. After oral administration of 2 boluses of rumbion (M/S Indian Herbs, Saharanpur) for 3 days, 3 of 3 calves recovered. The two untreated calves remained off-feed and had anorexia with atony of rumen and reticulum. After treatment with rumbion these calves also recovered. Various microbial cultures were tested as cattle feed additives (14).Four groups of newly born cross bred calves (average body weight 23.5 kg) were reared on green berseem and calf starter which was devoid of cereal grains. The incidence and duration of diarrhoea was lower in the animals of probiotic fed groups as compared to control group. Out of three microbial feed additives, yeast feeding showed maximum suppression of diarrhoea followed by *Lactobacillus* and curd. There was no effect of probiotic feeding on the log number of cells of lactic acid bacteria, yeast and coliform bacteria in the feces and rumen liquor at any age. The activities of carboxymethylcellulase, xylanase, beta-glucosidase, alpha-glucosidase, alpha-amylase, protease, urease and pH of the rumen liquor remained unaffected by probiotic feeding at all ages tested in this experiment.

Saponins and Essential Oils in Calves Feeding Systems

The flavor and aroma of herbs are provided by the essential oils that are found in the leaves, flowers, bark, roots or seeds of the plant. Essential oils are complex mixtures of aromatic substances that give the unique characteristic of each herb and are found in special cells in the plant called trichomes. Almost all herbs can be grown for the production of essential oils but the yield of oil from each species dictates whether this is commercially viable. England has historically been most famous for the production of lavender and peppermint oils; while saponins are natural detergents or surfactants found in a wide variety of plants. The major commercial saponin-contaning products are those derived from *Yucca schidigera* and *Quillaja saponaria. Yucca* is harvested from the wild in northern Mexico, while quillaja is a tree native to the Andes region of South America. It is harvested from the wild in Chile. Sada Andoa et al. (15) found that feeding herbs to dairy cattle may effect rumen fermentation and digestibility due to the herbs' physiological or pharmacological functions. Thus, in the present study, peppermint was tested for its effects upon digestibility and rumen fermentation. Digestion trials and an investigation of rumen fluid were conducted by four rumen-cannulated Holstein steers having or not having been fed peppermint. When peppermint was fed to the steers, the digestibility of nutrients tended to be higher than that of the control. Ammonia-nitrogen concentrations were higher in the control steers than in the peppermint-fed steers ($P<0.05$). Numbers of *Entodinum, Isotrica,* and *Diplodium* were decreased significantnly by the ingestion of peppermint ($P<0.05$). The total numbers of protozoa were significantly decreased by peppermint ingestion ($P<0.05$). Based on these results, it can be concluded that peppermint has a great potential as a natural manipulator of rumen fermentation by depressing ammonia-nitrogen concentration or number of protozoans.

Wallace (16) studied that increasing awareness of hazards associated with the use of antibiotic and chemical feed additives has accelerated investigations into plants and their extracts as feed additives. The present review mainly discusses two classes of plant secondary compounds in this context, i.e. essential oils and saponins. The broader potential of plants and their extracts is illustrated by the progress of an EC Framework 5 project, 'rumen-up'. Dietary inclusion of a commercial blend of essential oils causes merkedly decreased NH_3 production from amino acids in rumen fluid taken from sheep and cattle. This effect is mediated partly by the effects on hyper-NH_3 producing bacteria and the protein- and starch-fermenting rumen bacterium, Ruminobacter amylophilus. Saponin-containing plants and their extracts suppress the bacteriolytic activity of rumen ciliate protozoan and thereby enhance total microbial protein flow from the rumen. The effects of some saponins are transient, because saponins are hydrolysed by bacteria to their corresponding sapogenin aglycones, which are much less toxic to protozoan. Saponins also have selective antibacterial effects that may prove useful in, for example, controlling starch digestion. The 'rumen-up' project began with a targetted collection of European plants and their extracts,which partners have tested for their effects on rumen proteolysis, protozoa, methanogenesis and lactate production. A success rate of about 5% in terms of positive hits illustrates that plant secondary compounds, of which essential oils and saponins comprise a small proportion, have great potential as 'natural' manipulators of rumen fermentation to benefit the farmer and the environment in the future.

Callaway et al. (17) reported that microbial fermentation in the rumen dominates the nutrition of ruminant animals. Microbial ecosystems lend themselves to manipulation by external means, and it has long been clear that feed additives could be used to improve the nutrition of ruminants by manipulating ruminal fermentation. Ionophores and antibiotics have been used in the past to achieve some nutritional goals; however the recent ban of antimicrobial feed additives in the EU has lead to renewed interest in plants or their extracts as feed additives, with some success. This paper reviews recent progress in understanding how plants and thir extracts may be used as rumen manipulating agents.

Mineral Mixture in Calves Feeding Systems

To ensure better bio availability of minerals in animals body, enhance fertility in dairy animals, maintain and maximize the milk yields and milk fat. Most wheat pasture cattle are fed a mineral mixture, Aghashahi et al. (19) examined that the effect of various mineral additives Clinoptilolite (CL), natural Bentonite Montmorillonite (NB) and processed bentonite (PB) on growth, feed intake, carcass traits, rumen fermentation parameters (pH, amonia nitrogen) and population of rumen protozoan was studied 31 Holstein male calves (BW=273+0r-6 k and 210+or-20 days of age) were assigned to four rations for which levels of energy and protein were equal but with different mineral additives. The following rations given were : PB (ration 1), B (ration 2), CL (ration 3), and Placebo (ration 4). Calves were adapted to TMR rations for 25 days followed by 165 days of individual feeding. Average daily gain in calves receiving rations 1—4 were 1310.10, 1200.62, 1294.13, and 1107.38 g/day respectively. Feed conversion, rumen pH, rumen ammonia nitrogen feed rations 1—4 were 6.41, 6.63, 6.37, 7.10 and 0.5, 0.3, 0.1, 0.7 and 52.75, 55.51, 73.83, and 77.23 respectively. There was no significant difference in carcass traits for calves fed rations 1—4. It is suggested that PB and CL additives can help improved in fattening calves.

Saba et al (19) found that the influence of mineral and herbal mixtures given to calves on their hematological indices was studied. A group of calves was divided into four subgroups. A control group K had fodder supplemented with mineral mixture additive MMB. The experimental groups were fed the same fodder plus a mineral and herbal mixture supplement. Mixture A contained some herbs improving appetite, stimulating digestive processes and protecting the mucous membranes of the alimentary tract. Mixture B included some herbs activating and intensifying development of rumen microorganisms and stimulating the immune system. Mixture C had an appeasing effect that eliminated the stress results caused by some environmental factors. Blood was collected three times. Administration of the three different mixtures to the calves favorably influenced erythrocytes. It mainly involved increased erythrocytes count, higher haemoglobin content and mean cellular haemoglobin content. There was no effect of mixtures on leukocyte count.

Vitamins in Calves Feeding Systems

Vitamins are compounds necessary for the normal physiologic and metabolic functioning of the body. Vitamins do not share a common chemistry, but they do share certain characteristics. They are all organic nutrients that are necessary in small amounts for normal body functioning and good health. Your diet or any supplements you take provide most vitamins. The body can manufacture only three vitamins (D, K, and the B vitamin biotin) from nondietary sources. Unlike carbohydrates, fats, and proteins, vitamins are not sources of energy. Instead, vitamins are chemical partners for the enzymes involved in the body's metabolism, cell production, tissue repair, and other vital processes.

Vitamins are either fat soluble or water soluble. The fat-soluble vitamins, which include A, D, E, and K, are absorbed by the body using processes that closely parallel the absorption of fat. They are stored in the liver and used up by the body slowly. The water-soluble vitamins include vitamin C and the B complex vitamins. The body uses these vitamins very quickly. Excess amounts are eliminated in urine.

Vitamin E is a well-established micro-nutrient for all animal species. Vitamin E-based additives are globally used in animal nutrition, and have been for decades, to prevent vitamin E deficiency. Vitamin E occurs in nature and its use in animal nutrition will not result in a substantial increase in concentration in the environment. Therefore, no concern for the environment is expected.

Szarek et al. (20) examined on 20 calves, 1 day to 12 weeks of age, supplements of beta-carotene were fed in the form of rovimix beta-carotene 10%, artificially dehydrated carrot or vitamins AD_3E. PM examination at 12 weeks showed that supplementation of beta-carotene or vitamins AD_3E resulted in a better structural development of the ruminal papillae as compared to the control group. In addition, beta-carotene reduced the keratinization of the stratified squamous epithelial cell layer of the rumen and increased the glucose aminoglycan level of that organ wall.

Wejdemar (21) examined that why certain bacterial species generally tend to occur in greatest number in the rumen. By growing pure cultures of different rumen bacteria in clarified rumen fluid supplemented with glucose as the only added nutrient, *Prevotella ruminicola* grew most rapidly, followed by *Butyrivibrio fibrisolvens.* Growth rates of less numerous bacteria were much lower. By supplementing rumen fluid with glucose and yeast extract, several of the minority bacteria and *B. fibrisolvens*, grew as rapidly or even more rapidly than *P. ruminicola*. It was surmised that the growth-stimulating effect of yeast extract on the minority rumen bacteria could be due to vitamins. Results of growth experiments with supplementation of vitamins and an enzymatic hydrolysate of casein showed markedly increased growth rates for several strains of *B. fibrisolvens* and one strain each of *Eubacterium cellulosolves* and *Selenomonas ruminantium*. *P. ruminicola* did not react to the addition of vitamins but increased its growth rate when the enzymatic hydrolysate of casein was added. In the final experiment, rumen contents were not supplemented or supplemented with vitamins in an artificial rumen. The percentage proportions of the different bacterial species were altered by the additions. The results suggest that the proportional composition of the bacterial population in the rumen is regulated by the availability of vitamins such as biotin, folic acid, riboflavin and pyridoxine. This could indicate that feed additives may alter the proportions of different bacteria in the rumen.

The aim of this review is to collect the information regarding the effect of various feed additives e.g. antibiotics, ionophores, sulfonamides, probiotics, herbal drugs, microbial culture, saponins and essential oils, mineral mixture and vitamins including coccidiostats are being used to enhance the performance of livestocks including and rumen biology.

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