Role of nutraceuticals in livestock feed

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The prohibition of antibiotics as growth promoters, concerns about antimicrobial resistance, and consumer demand for drug-free animals and high-quality food products present challenges for breeders in the search for alternative methods to control and prevent pathogenic infections. Nutraceuticals offer a valuable solution as feed additives, focusing primarily on their host-protective functions, including antioxidant, anti-inflammatory, antimicrobial, and cell survival effects, with the aim of improving productivity.

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INTRODUCTION

These days, the use of nutraceuticals is receiving greater attention for the improvement of animal health, animal welfare, and productivity in herd health management. The term “nutraceutical” was coined in 1989 by Stephen DE Felice by combining the words “nutrition” and “pharmaceutical.”

According to Felice, a nutraceutical refers to any substance that is derived from food or is a part of food, and it offers medical or health benefits, including disease prevention and treatment. These products can include isolated nutrients, dietary supplements, specific diets, genetically engineered designer foods, and herbal products. Nutraceuticals distinguish themselves from other dietary supplements in various ways, including their ability to improve animal well-being and health without leaving any residues in meat consumed by humans. As a result, nutraceuticals can be seen as a blend of drugs and food nutrients, falling somewhere in between. They are considered safe and are recognized as alternative natural feed additives. Nutraceuticals exhibit pharmacological and biological activities, which can help combat drug resistance to antibiotics and often produce synergistic effects.

SELECTION CRITERIA OF NUTRACEUTICALS

The selection of nutraceuticals is determined by various factors, including their production, administration, application, colonial survival in the host, and physiological benefits. It is important for nutraceuticals to possess antimicrobial properties against pathogens. Additionally, they should have the ability to adhere to the intestinal epithelium and colonize the gastrointestinal tract (GIT) lumen, while exerting positive effects on animals. Nutraceuticals should be non-pathogenic, non-reactive, and non-toxic to ensure their safety. Furthermore, they should be capable of withstanding gastric acidity, bile salts, and digestive enzymes.

MODE OF ACTION OF NUTRACEUTICALS

The mode of action of nutraceuticals involves the ingestion of the nutraceutical substance, which is then followed by the release of active substances into the animal's body. These active substances attach to specific sites and carry out their intended functions. Eventually, they are excreted from the animal's body.

Nutraceuticals can employ various mechanisms to exert their effects, including:

1. Production of antimicrobial substances: Nutraceuticals can produce acids, bacteriocins, and antibiotics that have antimicrobial properties, helping to combat harmful organisms.

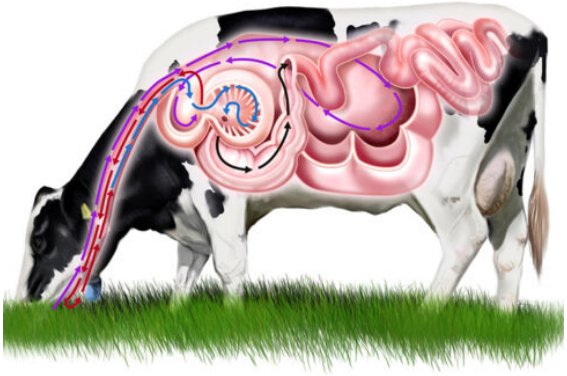
2. Competition for adhesion sites: Nutraceuticals can compete with detrimental organisms for sites where they would normally adhere, preventing the harmful organisms from establishing themselves.

3. Modulation of immune response: Nutraceuticals can enhance the immune response by increasing the phagocytic activity of macrophages and natural killer cells, which are important components of the immune system.

4. Reduction of bacterial toxin metabolism: Nutraceuticals can help reduce the metabolism of bacterial toxins, limiting their negative effects on the body.

5. Variation of enzyme secretion: Nutraceuticals may have the ability to influence the secretion of certain enzymes, which can impact various physiological processes in the body.

These mechanisms illustrate how nutraceuticals can exert their beneficial effects on animals by interacting with different biological processes.



PROBIOTICS AS NUTRACEUTICALS

In dairy production, nutraceuticals are commonly employed to enhance milk yield and quality, as well as promote animal health by reducing acidosis and improving feed efficiency. They achieve this by increasing dry matter consumption and facilitating energy production and microbial protein synthesis. Nutraceuticals also contribute to the reduction of somatic cell count in milk, which is indicative of udder health. Furthermore, they have been studied as potential alternatives to antibiotic growth promoters (AGPs) in livestock.

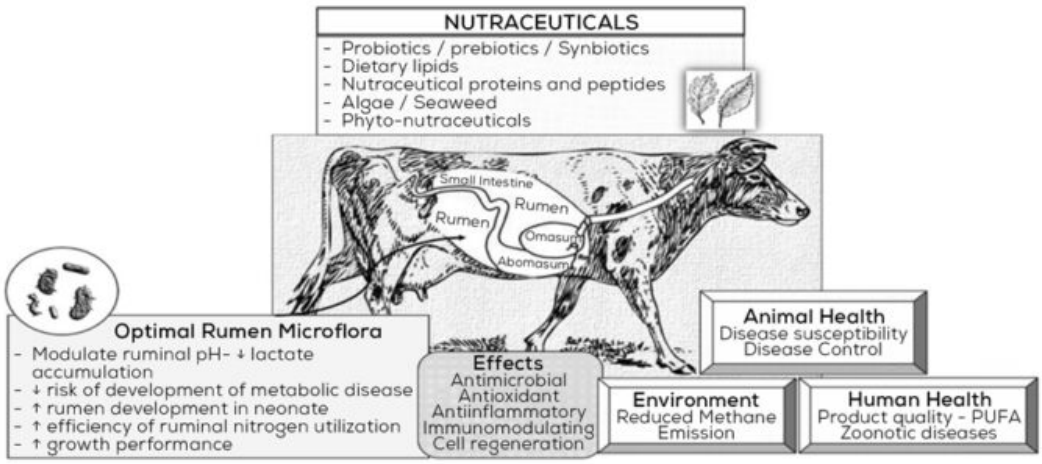
Probiotics, specifically used as nutraceuticals, primarily aim to improve animal health in the face of various infectious agents, rather than solely focusing on normal nutrition. These probiotics have shown promise in enhancing gut morphology, gut health, and nutrient absorption. As a result, animal owners are increasingly considering the supplementation of probiotics to support intestinal health and improve production performance in farm animals. Probiotics have been observed to stimulate the growth of beneficial bacteria such as bifidobacteria and lactobacilli, resulting in significant alterations to the gut microbiota composition.

PREBIOTICS AS NUTRACEUTICALS

Prebiotics refer to non-digestible food ingredients that have a positive impact on the host by selectively stimulating the growth or activity of bacteria in the colon, thus promoting overall host health. These compounds are not absorbed in the upper gastrointestinal (GI) tract due to their chemical nature. One category of prebiotics includes non-digestible carbohydrates found in various food ingredients.

Specific types of prebiotics, such as galactooligosaccharides, mannan-oligosaccharides, and fructo-oligosaccharides, are commonly used as feed additives to modify gut microbes and stimulate the intestinal immune system. Oligosaccharides can stimulate the growth of beneficial bacteria in the gut, particularly lactobacillus and bifidobacterium. These beneficial bacteria utilize oligosaccharides as substrates, promoting their own growth. Furthermore, the stimulation of bifidobacteria by providing oligosaccharides may help prevent the attachment and colonization of the gut epithelium by pathogenic bacteria.

In summary, prebiotics, particularly oligosaccharides, serve as non-digestible food ingredients that selectively stimulate the growth of beneficial bacteria in the colon, thereby enhancing the host's health and contributing to the prevention of pathogenic bacterial attachment and colonization in the gut.



SYNBIOTIC AS NUTRACEUTICALS

The combination of prebiotics and probiotics has been shown to have synergistic effects, surpassing the individual effects of probiotics or prebiotics alone. This combination promotes the survival and deposition of viable beneficial microorganisms, helping to maintain a healthy natural microbial environment in the rumen.

In the context of synbiotic fermented milk, which contains specific strains such as S. thermophilus, L. acidophilus, and Bifidobacterium bifidum, the addition of active ingredients from herbal hydrosols and honey (such as apple acid) has been evaluated. The effects of this synbiotic combination on sexual activity, semen characteristics, and testosterone levels were examined. The findings revealed enhanced libido and improved semen physical characteristics when compared to control groups.

Overall, the use of synbiotic combinations, where prebiotics and probiotics work together, has demonstrated greater efficacy in various aspects such as rumen health and reproductive function when compared to the isolated use of either prebiotics or probiotics alone.

DIETARY LIPIDS AS NUTRACEUTICALS

Dietary lipids play crucial roles in nutrition and biological functions. They serve as sources of essential fatty acids and energy, while also enhancing the absorption of fat-soluble nutrients. In the case of dairy cows, their diet primarily consists of polyunsaturated fatty acids (PUFAs). PUFAs serve as precursors for prostaglandin synthesis, which in turn modulate key enzymes involved in prostaglandin and steroid metabolism. This modulation leads to improved male reproductive performance, as PUFAs are vital for maintaining sperm membrane integrity and have beneficial effects on sperm motility, viability, and testis development. Consequently, fertility parameters in ruminants are enhanced.

Furthermore, the inclusion of PUFAs in the diet has been shown to modulate the immune response through various mechanisms. This includes reducing tissue levels of immunosuppressive agents like arachidonic acid and prostaglandin E2. These immunomodulatory effects are particularly important in reducing stress during transportation and the entry of ruminants into feed yards. Additionally, PUFAs have the potential to alter the composition of fatty acids in milk, while also improving productive performance and metabolic health.

When incorporating PUFAs into diets, it is crucial to consider sources that are protected from rumen biodegradation. This is important to ensure their effective utilization and benefits. Another significant benefit of PUFA-enriched diets, such as those rich in linseed or supplemented with fish oil, is their potential to mitigate enteric methane production. As methane is a greenhouse gas produced in the rumen, reducing its emissions is a social and environmental priority.

In summary, dietary lipids, particularly PUFAs, have important functions in nutrition and biological processes. They contribute to reproductive performance, immune modulation, milk fatty acid composition, and overall animal health. The selection of appropriate PUFA sources is crucial for their effective utilization, while also considering their potential in reducing methane emissions in ruminants.

NUTRACEUTICAL PROTEINS AND PEPTIDES

Biologically active peptides refer to specific protein fragments obtained through natural enzymatic digestion or fermentation of food products. These peptides play a role in promoting bodily functions, improving overall health, and aiding in the prevention and treatment of diseases. Depending on their type and concentration, these peptides have various effects on the body, such as enhancing nutrient absorption, bolstering the immune system, regulating bodily processes, and supporting the nervous system. In the context of ruminants, nutraceutical proteins and peptides like casein phosphopeptides (CPPs), milk whey protein, egg white proteins, soybean proteins, and antimicrobial peptides are commonly used. These compounds have the ability to bind and make macro elements (such as calcium, magnesium, and iron) as well as trace elements (such as zinc, barium, chromium, nickel, cobalt, and selenium) more soluble. CPPs, for example, have potential applications in preventing conditions like osteoporosis, hypertension, anemia, and dental caries. Additionally, they can contribute to the humanization of bovine milk by increasing phosphorus levels.

Whey has been found to enhance the quality and digestibility of grass and legume silage, while also reducing concentrations of ammonia nitrogen. In addition, whey has a positive impact on the growth rates of calves. When whey protein is formulated into an emulsion gel, it acts as a protective barrier, preventing unsaturated fatty acids from undergoing rumen biohydrogenation. This preservation allows for better absorption of these compounds in the small intestine, ultimately leading to their incorporation into milk fat.

Egg white proteins, including ovalbumin, Ovo transferrin, ovomucoid, ovomucin, and lysozyme, show significant potential for application in the food and pharmaceutical industries. These proteins possess antimicrobial, anticancer, antioxidant, metal-binding/transporting, and nutrient supplementation properties in organisms.

Soybean peptides have the remarkable ability to bind to bile acids, reducing cholesterol levels by inhibiting the reabsorption of bile acid in the ileum. Black soybean peptides have demonstrated antidiabetic effects by suppressing hepatic endoplasmic reticulum stress and maintaining insulin resistance. Properly processed soybeans have been shown to increase milk production and promote growth.

Lactoferrin, an iron-binding glycoprotein with antimicrobial and antioxidant properties, exhibits various beneficial effects. It interferes with the adhesion and colonization of microorganisms, detaches them from biological surfaces, inhibits their multiplication, neutralizes endotoxins, and enhances the immune system. As a result, lactoferrin shows potential for use against foodborne pathogens and also demonstrates antiviral, antifungal, and antiparasitic activities.

PHYTONUTRACEUTICALS

Plant extracts containing secondary metabolites offer a diverse range of chemical structures and biological activities, making them valuable resources for pharmaceutical applications. In ruminant farming, these secondary compounds have been utilized as alternatives to conventional drug treatments and for their potential to enhance productivity. The demand for and interest in plant secondary compounds have grown, driven by the goal of improving meat and milk quality and

enhancing immunity against pathogenic diseases.

Phenolic compounds, such as tannins, are among the major secondary metabolites used in farming systems. The effects of tannins on ruminal health vary depending on the animal species, ruminal pH, and the type and concentration of tannins employed. Tannins form complexes that are resistant to digestion and reduce the turnover rate in the rumen, allowing them to be eventually available in the intestine. This improves protein digestion efficiency and enhances animal health. Additionally, tannins have anthelmintic effects on larval motility, offering benefits in managing internal parasites.

Tannins also influence lipid metabolism in ruminants. Depending on the biohydrogenation steps, microbial species, and the animal's physiology, tannins can increase the presence of beneficial fatty acids, such as linolenic acid, vaccenic acid, and rumenic acid, in meat and milk.

Saponins, another group of secondary compounds, exhibit a wide range of biological effects, including hypocholesterolemia, hypolipidemic properties, immune stimulation, anti-inflammatory activity, antioxidant effects, neurohepatoprotective properties, anticarcinogenic activity, and antifungal effects. Saponins have been associated with inhibiting dental caries and platelet aggregation. However, it's important to note that certain types of saponins can form a stable foam in the rumen due to their detergent properties, leading to issues such as forestomach motility inhibition, photosensitization, liver and kidney degeneration, and other gastrointestinal problems.

Furthermore, saponins have shown the potential to enhance the effectiveness of oral vaccines by modifying the permeability of the oral mucosa and exhibiting immune-enhancing properties.

APPLICATION OF NUTRACEUTICALS

1. Nutraceuticals offer a valuable approach for preventing and managing diseases in ruminants by exerting antioxidant, anti-inflammatory, and antimicrobial effects.

2. Nutraceuticals that positively influence the rumen microbiota have the potential to enhance productivity and profitability. This is because the rumen plays a crucial role in both the immune system and overall nutrition.

3. The benefits of nutraceuticals extend beyond cattle health and also have positive effects on the environment, particularly in reducing methane emissions.

4. Nutraceuticals contribute to improved feed quality and increased palatability for ruminants.

5. The use of nutraceuticals enhances feed conversion efficiency and promotes animal growth. Additionally, it helps mitigate environmental stress.

6. Nutraceuticals support the enhancement of immune responses, thereby increasing the immunity of ruminants against diseases.

7. The utilization of nutraceuticals leads to an improved quality of final animal products, which can have positive implications for the market value of these products.

EXAMPLES OF NUTRACEUTICALS

Gou mix, Garbhamin, Inimixforte, Mxtcare, Govit, Gousac, Godharashakti, Bovoplex oral

CONCLUDING REMARKS

The prohibition of antibiotics as growth promoters, concerns about antimicrobial resistance, and consumer demand for drug-free animals and high-quality food products present challenges for breeders in the search for alternative methods to control and prevent pathogenic infections. Nutraceuticals offer a valuable solution as feed additives, focusing primarily on their host-protective functions, including antioxidant, anti-inflammatory, antimicrobial, and cell survival effects, with the aim of improving productivity.

Several major nutraceutical compounds have shown potential in ruminants, including dietary fiber, probiotics, prebiotics, dietary lipids, proteins and peptides (including antimicrobial peptides), and phytonutrients such as tannins and saponins. In ruminants, the rumen microbiota plays a crucial role in both the immune system and nutrition, making nutraceuticals expected to primarily exert rumen-modulating effects.

Ruminant livestock production has an environmental impact, particularly through the emission of methane and the excretion of nitrogen in significant quantities, contributing to global methane emissions. Therefore, nutraceuticals not only play a vital role in ruminant health but also have the potential to influence public health by inhibiting methane emissions and reducing the presence of pathogenic bacteria in food products derived from animals.

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