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Research Paper

The Functional Feed Additives in Animal Nutrition: The Substitute to Antibiotics

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ABSTRACT: *Animal production is affected by a number of both external and internal factors that unequivocally include nutrition. Feed additives are products used in animal nutrition to improve the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health. There is a growing range of feed additives, aimed for use in ruminant diets. They are supplemented in small amount for specific purpose. Feed containing functional feed additives promote the growth and health of the animal by improving digestibility, antimicrobial, anti-inflammatory, antioxidant and the immune system which will induce physiological benefit beyond traditional feed. Use of expensive antibiotics for controlling disease have widely been criticized for their negative impact like residual accumulation in the tissue, development of the drug resistance and immunosuppression, thus resulting in reduced consumer preference for food animal treated with antibiotics. Hence, instead of chemotherapeutic agents, increasing attention is being paid to the use of feed additives for disease control measures. Current evidence shows that due to ban on use of certain antibiotics, harmful residual effects and cost effectiveness the use of feed additives for the prevention of animal diseases and for the production of food products of improved quality is considered an attractive and promising approach. A number of feed additives like probiotics, prebiotics, organic acids and plant extracts have been found to have beneficial effects on animal production. To be sustainable and taken up by the industry, the feed additive would need to be effective over long periods of time, non-toxic for animals, the environmental and consumers and cheap enough for standard use in animal feeds. Overall, most additives require further long term studies in the live ruminant to determine how effective they are in commercial systems and to enable the standardization of correct dosages of these products to livestock nutrition.*

KEY WORDS: *Animal nutrition, Antimicrobial, Anti-Oxidant, Immune-Stimulant, Feed Additive*

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I. INTRODUCTION

Farm animal populations are undergoing continuous selection to improve the economic efficiency of animal production. Animal production itself is affected by a number of both external and internal factors that unequivocally include nutrition. Animal feeds are formulated with a vast pool of ingredient to meet nutritional requirements for normal physiological functions, including maintaining a highly effective natural immune system, growth, and reproduction. To ensure the dietary nutrients are ingested, digested, absorbed, and transported to the cells, an increasing diversity of non-nutritive feed additives are being used in animal feeds (1).

Feed additives are products used in animal nutrition to improve the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health. Feed additives are supplemented in small amounts for a specific purpose. Feed containing functional feed additives promote the growth and health of animal, improve their immune systems, and induce physiological benefits beyond traditional feeds. Probiotics, prebiotics, phytogenic substances, immune-stimulants, enzymes, hormones, mycotoxin binders, organic acids etc., are best functional feed additives to manage and regulate animal performance and improve farm profit (2).

Products that improve feed efficiency are particularly important since feed costs are a major expense in animal production. Non-nutritive feed additives are being used in animal feeds to ensure ingestion, digestion, and absorption of dietary nutrients. Feed additives may be both nutritive and non-nutritive ingredients and work by either direct or indirect methods on the animal's system (3). According to (4), feed additives are supplemented in small amounts (alone or in combination) for a specific purpose, such as to improve the quality of animal as a final product, to preserve the physical and chemical quality of the diet or to maintain the quality.

The range of feed additives used in animal feeds is very diverse. Additives are used in feed to preserve the nutritional characteristics of a diet or feed ingredients prior to feeding (e.g. antioxidant and mold inhibitors) (5), enhance ingredient dispersion or feed pelleting (e.g. emulsifiers, stabilizers and binders) (6), facilitate feed ingestion and consumer acceptance of the product (e.g. feed stimulants or attractants) (7) and promote growth (e.g. growth promoters, including probiotics and hormones) (8). Enzymes also used to improve the availability of certain nutrients (e.g. proteases, amylases) or to eliminate the presence of certain antinutrients (e.g. phytase) (9).

Types and roles of functional feed additives in animal nutrition

Nowadays, there are more sustainable ways to modulate the health and performance of animal by supplementing feeds with functional foods. Functional feed (feed containing functional feed additives) promote the growth and health of cultivated organisms, improve their immune systems, and induce physiological benefits beyond traditional feeds. According to Barrows et al. (10), feed additives can be categorized into: (1) additives that affect performance and health (functional feed additives) and (2) additives that affect feed quality and feed up take. There are several options available to manage and regulate performance and health such as the animal gut environment which includes probiotics, prebiotics, immune-stimulants, phytogenic substances, enzymes, hormones, mycotoxin binders and organic acids (11).

There are also different feed additives such as pellet binders, attractants, antioxidants, color/pigmentation agents and antimicrobial compounds used to maximize feed up take and maintain feed quality in tilapia culture (12).

Phytogenic substances: Phytochemicals are plant-derived compounds, such as essential oils or tannins that may have antibacterial and growth promoting effects (13). Different essential oils vary in antibacterial mode of action, which is often not well characterized (14). Phytochemicals are used on commercial poultry operations for growth promotion as well as disease prevention, (15) and a recent opinion issued jointly by EMA and EFSA concluded that these compounds are effective in promoting growth in chickens but that efficacy depends, at least to some degree, on the part of the plant used (16) The same conclusion regarding efficacy was reached in a meta-analysis, (17) and some scientific studies have demonstrated that phytochemicals can improve the gastrointestinal health of broiler chickens and reduce levels of coccidian parasites (18). Some studies have shown positive effects for disease prevention as well as growth promotion in pigs, but others have failed to detect such effects (19). In adult cattle, a recent meta-analysis concluded that the available data are insufficient to reach a final.

Probiotics: Probiotics are live cultures of microorganisms (e.g., yeast, fungi, and bacteria) that are added to the diet to improve the balance of microbial communities in the gastrointestinal tract (20). Probiotics can be distinguished as "defined" and "undefined." Defined probiotics consist of single strains or mixtures of comprehensively described microorganisms (e.g., each organism is described to the species level, the exact composition of the culture is quantitatively described, and the genomes of individual organisms in the mixture may have been fully sequenced to assure the absence of any antibiotic resistance genes). Undefined probiotics tend to consist of microbial mixtures that are not completely described (21). In general, undefined probiotics tend to have higher efficacy than defined probiotics, but both are promising approaches for disease prevention and, in some instances, treatment that may also lead to better production performance and thus growth promotion (22).

Probiotics are widely used in U.S. poultry operations, (23) and an FAO report has concluded that probiotics can have significant positive effects on the productivity and health of poultry (24). A number of scientific studies have quantified the efficacy of probiotics for growth promotion and disease prevention in chickens and turkeys. For example, one study reported that probiotics improved productivity and intestinal health in newly hatched birds and reduced mortality by over 20 percent compared with control flocks; the reduction in mortality was similar to that achieved with antibiotics (25). The use of probiotics in laying hens has resulted in statistically significant increases in productivity, measured in terms of egg production (26). In an experiment comparing in-feed enzymes to a mixture of probiotic strains, both products significantly reduced broiler mortality and improved production efficiency compared with animals fed a diet that contained neither product. Probiotics, however, showed significantly better results than in-feed enzymes. In fact, a study demonstrated that a wide range of probiotic bacteria can effectively control the clinical symptoms associated with coccidiosis, a potentially devastating poultry disease that tends to be difficult to control without antibiotics. This study compared the efficacy of probiotics to that of ionophores, a class of antibiotics not important for human medicine but used against coccidiosis in birds, and found comparable results, therefore probiotics can significantly decrease the need to use ionophores to prevent diseases associated with coccidiosis (27).

Probiotics have shown promise for disease prevention in cattle, (28) as well as enhancing a variety of production parameters, and probiotics are widely used commercially in cattle. According to recent data, 20 percent of U.S. dairy operations use probiotics to prevent disease in dairy cows, and to improve health and productivity in dairy calves (29). Similarly, more than 1 in 4 large feedlots with more than 1,000 cattle uses probiotics to prevent disease (30). An FAO report as well as several meta-analyses, and systematic reviews have concluded that probiotics are effective at enhancing productivity and preventing or treating disease in beef as well as dairy cattle and calves (31). A number of scientific studies have quantified the impact of probiotics for these purposes. In one study, for instance, probiotic use increased milk production efficiency (measured as kg milk produced/kg feed consumed) in dairy cows by 6 percent (32). While overall more scientific studies have evaluated the impact of probiotics on growth promotion than on disease prevention in cattle, positive impacts on the latter have also been repeatedly demonstrated (33)

For all species, storage and administration of probiotics poses a potential challenge. For instance, to create feed pellets, chicken feed is usually exposed to high heat during manufacturing, which may inactivate probiotics, although that problem does not seem to exist in other feed forms (34). Because live cultures are administered, probiotics have some associated risks, for example potential unintended, undesired, and detrimental changes in the microbial balance of the gut.

Prebiotics: A prebiotic was defined as: ‘a nondigestive food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health’. They are organic compounds such as certain sugars that, when added to the diet, are indigestible by animals but are broken down by certain beneficial microorganisms in the gut, which selectively stimulates these and other microorganisms’ growth (35).

Prebiotics thereby can favor the presence of beneficial microorganisms in the intestine. Both prebiotics and probiotics help beneficial microorganisms to outcompete harmful bacteria but may also have other effects such as modulating the immune system. However, the various ways in which these products work and the diverse biological impacts they can exert-for instance, on the immune systems of animals that ingest them are not completely understood.

Contrary to the situation for probiotics, the use of prebiotics as growth promoters and for disease prevention has shown inconsistent efficacy. In general, the efficacy of prebiotics seems to be determined by a variety of factors, including the type of prebiotic, animal age and species, animal health status, the housing type, and management practices, all of which have to be considered in the decision whether to use these alternatives (29).

Prebiotics are used commercially in chickens and turkeys for growth promotion and disease prevention as well as to improve overall gut health, according to expert elicitations (36). A recent review by EMA and EFSA concluded that prebiotics are effective at promoting growth and reducing disease (37). Although studies evaluating the efficacy of prebiotics for disease prevention in chickens are fairly limited, significant reductions in the shedding of pathogens and improvements in gut health have been described (38) However, efficacy appears to be variable, (39) and some products such as fructo-oligosaccharides or mannan appear to be more effective than others (40).

In pigs, some studies have reported positive growth promoting effects of prebiotics with increases in average daily gains of up to 8 percent in pigs immediately after weaning, (41), but other studies have failed to find a statistically significant impact on growth (42). In pigs fed a diet containing prebiotics, probiotics can also enhance immune responses against intestinal infections such as salmonellosis (43)

In cattle, prebiotic efficacy seems to be limited to young calves. The addition of some prebiotics to milk replacers (i.e., the liquid feed given to young calves not nursed by their mothers, primarily on dairy farms) has been shown to promote growth and prevent disease in young dairy calves (44). In these animals, average body weight gains were significantly greater when fed a diet of milk replacers with a specific type of prebiotic (galactosyl-lactose) than when fed a diet of milk replacer without prebiotic (45). Even though relatively few studies have evaluated the efficacy of prebiotics for disease prevention in young calves, statistically significant improvements in gut health have been reported (46). However, young calves differ from older cattle because the rumen, the part of the animal’s digestive tract that helps break down complex carbohydrate plant materials such as cellulose, is not fully developed until the calf begins to ingest plant materials. Prebiotics are quickly digested in the fully formed rumen, and thus are rendered ineffective (47).

Prebiotics bring about a specific modulation of the gut microbiota, particularly increased numbers of bifidobacteria and/or lactobacilli cell counts or a decrease in potential harmful bacteria is a sufficient criterion for health promotion (46). The most common prebiotics used in animal are carbohydrates like inulin, fructooligosaccharides, shortchain fructooligosaccharides, oligofructose, mannanoligosaccharides, trans-galactooligosaccharides, which are nondigestible but can be fermented by the intestinal flora (45,47).

Mycotoxin binders: Mycotoxins are toxic metabolites produced by a diverse group of fungi (e.g. Aspergillus) that contaminate agricultural crops prior to harvest or during storage post-harvest (39). Mycotoxins represent a serious problem in animal production worldwide. Its effects includes reduction of weight gain and feed efficiency, causing liver and kidney damage, worsening the overall health of the fish and which can result in serious economic implications to farmers (40,41). According to (42), 0.5% of hydrated sodium calcium aluminosilicates (HSCAS) effectively reduced aflatoxin B1 (AFB1) toxicity in O. niloticus. HSCAS binds aflatoxin in the gastrointestinal tract, thereby reducing overall bioavailability to the bloodstream.

Immunostimulating agents: Immunostimulants comprise a group of biological and synthetic compounds that enhance the non-specific cellular and humoral defense mechanism in animals. These substances such as levamisole and glucan, peptidoglycon, chitin, chitosan, yeast and vitamin combinations as well as various products derived from plants and animals are effective in prevention of diseases (49). Use of expensive chemotherapeutants and antibiotics for controlling disease have widely been criticized for their negative impact like residual accumulation in the tissue, development of the drug resistance and immunosuppression, thus resulting in reduced consumer preference for food fish treated with antibiotics (50).

An immunostimulant is a naturally occurring compound that modulates the immune system by increasing the host's resistance against diseases that in most circumstances are caused by pathogens (51). O. niloticus supplied with diet containing plant additives 0.25% E. purpurea, 3% garlic (A. sativum) or 3% Nigella sativa showed higher survival in response to challenge infection than fed on control (without additives) (52).

In practice, immunostimulants are the promising dietary supplement to potentially aid in disease control of several organism and increase disease resistance by causing up regulation of host defense mechanism against opportunistic pathogen microorganisms in the environment. Immunostimulants also have ability to increase resistance to viral, bacterial and fungal infection (52).

Organic acids: Organic acids, such as citric or acetic acids, are also promising alternatives for growth promotion and disease prevention. Similar to the alternatives previously discussed the mechanism by which organic acids function as growth promoters when added to feed or drinking water is not well understood. It is likely that an organic acid's ability to kill bacteria contributes to its growth promotion property; in addition, organic acids may affect gut microflora by favoring the growth of certain acid-loving beneficial bacteria, and improve the physiological functions of the stomach by increasing its acidity levels (48). A recent joint opinion by EMA and EFSA concluded that organic acids are effective growth promoters in chickens and can successfully prevent disease in these animals, even though efficacy is variable (49). In swine, a meta-analysis concluded that organic acids have demonstrated some, albeit variable, efficacy as growth promoters and a review has concluded that organic acids have positive impacts on disease prevention, measured for instance in the form of reduction in gastro-intestinal illness and diarrhea in piglets (50). Some studies in cattle have also demonstrated a positive effect of organic acids on performance and the prevention of certain digestive diseases such as rumen acidosis, but more data are needed (51).

Individual studies have further quantified the impact of organic acids on growth promotion and disease prevention. Adding organic acids to the diet has been described as exerting direct positive growth effects, with improvements in weight gain in broiler chickens and grain-fed beef cattle of around 17 percent and more than 8 percent, respectively (52). Promising results have also been described in pigs, although here efficacy may differ by production class and its use may be contraindicated in specific cases, for instance in sows because of potential negative impacts on their milk production (53). In-feed organic acids also may reduce pathogen survival in the gut (54).

One study, for instance, found that organic acid supplementation in piglets significantly reduced the incidence and severity of post-weaning diarrhea syndrome compared to pigs fed a diet without supplementation of organic acids (55).

II. CONCLUSION

Keeping farm animals healthy is necessary to obtain healthy animal products. For the last decade the use of additives of natural origin in animal and human nutrition has been encouraged. Numerous researches focused on the clarification of the biochemical structures and physiological functions of various feed additives like probiotics, prebiotics, organic acids and plant extracts. To gain advantageous effects of herbs and spices, they can be added to feed as dried plants or parts of plants and as extracts. But there need of research on various properties of specific herb for improving digestibility, antimicrobial, anti- inflammatory, anti-oxidant, immunostimulant effect and their effect dosages.

A variety of products and management practices may eventually be able to replace a substantive proportion of current antibiotic use for prevention and growth promotion purposes, but this effort will require a comprehensive approach that considers alternatives as one part of a herd health management program.

Overall, alternatives to antibiotics are promising, as many appear to simultaneously enhance animal productivity and prevent infection, both of which hold much appeal to food animal producers. However, in several instances, efficacy has been evaluated only experimentally, which probably neither reflects real-world husbandry conditions on commercial operations nor the target animals (e.g., studies are often conducted in calves or piglets while the intervention would ultimately be applied to older animals). In other cases, the approach might be broad and indirect but effective, such as biosecurity measures. Potential unintended consequences have generally not been well studied. Typically, cost-effectiveness data are also not available, complicating the evaluation of incentives for implementation.

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