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Organic Acids as feed additives in poultry and swine

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Abstract

As the increasing safety concerns about the risk of spreading antibiotic resistance in humans and environment and the detection of chemical residues in animal derived products, using organic acids (OAs) to replace antibiotic in the diet of farm animals and poultry industry has been increased considerably in recent years. Through their potential to modify the pH of the gastrointestinal tract and subsequently the genetic profile of microbiome, organic acids have shown promise in improving production performance. Since poultry and swine industry are the major part of today's livestock sector, improving their growth and performance undoubtedly raise the overall economic gain from livestock enterprise.

Key words: organic acids, microbiome, poultry, production performance

Introduction

Present day livestock and poultry rearing practices are much advanced and intensified to fulfill the demand of animal derived products. To exploit full elite genetic potential of animals, several strategies are being used and applied at large scale. One of such strategy includes addition of feed additives in diets of animal. Although, feed additives added in minute quantities but have major impact on production performance of the animal. Discovery of antibiotics lead to rise of new era with hope for treatment of seemingly incurable infectious diseases. Sooner the mass use of antibiotics started as feed additives in diets of livestock and poultry in order to control subclinical infections and preventive measure against ailments. By decreasing the count of bacteria in the gastrointestinal tract (GIT) and thereby lowering nutrient competition among microorganisms, decreasing immunological stimulation, preventing thinning of the intestinal epithelium and improving nutrient digestibility, antibiotics have been shown to improve weight gain. Their use undoubtedly increased production performance but one of worse situation was also rising insidiously. Anti-microbial resistance was globally risen concern which threatens the life of humans and challenged food security. The Swann Committee under European Union (EU) in 1960s, evaluated the chain of arise of antimicrobial resistance from administration of antibiotics in livestock. In relation to its data interpretation and study results, it was suggested to

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forbid the use of sub therapeutic dose of antibiotics in animals. Consequently, EU in January 2006 prohibited the use of antibiotics in animals as feed additives to enhance growth and production. Many alternatives as feed additives came into use after the ban of antimicrobial agents. Probiotics, prebiotics, acidifiers, antioxidants, essential oils, phytobiotics, hormones, etc. were commonly added in diets of animal to improve growth rates. Since GI microbes have diverse role in normal physiologic function of their host, any dysbiosis in microbial population directly affects health and productivity level which can have adverse effects on economy of the livestock enterprise. Maintaining healthy gut environment appears to be crucial for maximum nutrient utilization and to get optimum production from the animal.

Organic acids (OAs) or Acidifiers

The word "organic acid" describes all those acids having hydrogen and carbon with combination of other element giving rise to functional group -COOH, and is wide class of substances that are utilized in the body at various levels of metabolic processes. They are further categorized into different classes according to the length of carbon chain in their structure. They can be classified as short chain fatty acids (formic acid, lactic acid, malic acid, acetic acid, tartaric acid, propionic acid and butyric acid), medium chain fatty acids (caproic acid, lauric acid), long chain fatty acids (linolenic acid, linoleic acid) and very long chain fatty acids.

Action mechanism of OAs

There are differences in the antibacterial action of different organic acids. The length of the carbon chain and the degree of unsaturation affect the effectiveness against microbes, but the acid's overall antimicrobial action is majorly influenced by its pKa (dissociation constant) value. All organic acids are, in fact, identified by a pH level at which half of the acid is present in a dissociated form and remaining as un-dissociated from. pKa indicates the strength of an acid i.e. lower the pKa value, higher is the acidic property. pKa range from 3 to 5 is particularly associated with antibacterial action of weak organic acids.

Majority of bacterial species need a certain pH to flourish at their best and they cannot develop in extremely acidic environments. Acidifiers exhibit their antibacterial activity mainly by two mechanisms. In first type of action, the OAs lowers the pH of stomach of the host animal and thus aids in destroying harmful acid liable bacteria indirectly. Moreover, lowered pH of stomach helps in protein digestion as it denatures protein structure, enhances pepsin activity and stimulates pancreatic secretion rich in trypsinogen, chymotrypsinogen A, chymotrypsinogen B, procarboxy peptidase A and procarboxy- peptidase B.

In second type, OAs in their un-ionic form enter the intracellular compartment of bacteria by penetrating their cell wall and then breakdown into proton and anion which disrupts normal cell physiology resulting in death of microorganism. Harmful bacteria tend to increase nutrient

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competition with that of cells of host animal's intestine. Furthermore, bacteria produce toxic compounds during their cellular metabolism which themselves impairs fat digestion, causing absorptive epithelial cells to turnover quickly, demanding the intestine goblet cells to secrete mucus at an accelerated rate and also stimulate the immune system and inflammatory responses of the host animal. As consequence of all these unnecessary effects, the growth of animal is compromised and hence the productivity. So, OAs directly destroys such adversely affecting microbes and helps in controlling their population inside gut.

By increasing the activity of proteolytic enzymes and nutritional digestibility, delaying gastric emptiness, enhancing pancreatic secretions, elevating mineral absorption, boosting the activity of digestive enzymes, stabilizing the microbial population, fostering the growth of favorable bacteria and acting as bacteriostatic and bactericidal agent against infectious pathogens, OAs tends to improve the conditions of the GIT.

OAs in poultry

Use of OAs in poultry has revealed several beneficial effects on the GI tract of bird and aided in reaching desired growth rates and feed efficiency. They are frequently used feed additives in poultry diet. Growth of undesirable bacteria and thereby release of toxic metabolites have negative effects on villus height and width. Affected intestine reveals decreased nutrient absorption, thinning of epithelial cells and compromised intestinal integrity. Increased permeability of tight junctions of intestine paves easy entry of pathogens and that induces inflammatory and immune responses. Numerous dietary trials conducted in poultry indicated the positive effects of supplementation of OAs in terms of increased intestinal villus height, villus width and lowered crypt depth. OAs reduces colonization of harmful microbes and thus aids in maintaining healthy intestinal environment and minimizes immune stimulations. Favorable effects of OAs against common pathogens include *E. coli, Eimeria* oocyst, *Salmonella, Enterococcus*, infectious bursal disease and Newcastle disease.

OAs are natural products so the problem of residues in animal products or rise of anti-microbial resistance is completely avoided. As the result of enhanced nutrient utilization, feed conversion ratio and feed efficiency in birds also observed to be better. Many trials on poultry specified the stimulatory effects of OAs on immune system and increased serum antibody titres against infectious diseases.

OAs in pig

Likewise in poultry, OAs also revealed beneficial effects on the growth performance and economy of swine industry. There is continuous exchange of molecules between hindgut microbiome and gut mucosa of pig which is observed as stimulation of host immune system and control over various physiological functions which has significant valuable effects on growth

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traits. Different factors like age, genetics, diet and particular gut environment affects the growth, profile and structure of microbiome in gut. Among these variables, nutrition is one of the most important ones that can quickly alter the microbial composition associated to the gut. As the piglets have limited ability to secrete stomach acid, supplementation with OAs found to be useful to lower the stomach pH and aids in protein digestion. Moreover, intestine cells matures earlier in presence of butyric acid, hence OAs improves nutrient digestion and overall feed utilization.

Alteration in the composition of the intestinal microbiota led to a shift in the SCFA derivative that results from the bacterial fermentation of carbohydrates, primarily acetate, propionate and butyrate, which may be used by the host for energy metabolism. Average daily gain, body weight gain and feed conversion ratio were found to be positively affected from OAs in diet of swine in pre-weaning and post-weaning age.

Conclusion

OAs serves a crucial role as being potent alternative to antibiotic feed additives. Various effects are observed on different parameters of poultry and swine. Increasing apparent total digestive tract digestibility, lowering stomach pH, limiting the growth of pathogens, providing energy during GIT intermediate metabolism and enhancing growth performance are overall benefits of adding OAs in diet of poultry and pig. OAs found to be advantageous as they have no residual effects on animal body including its products and environmental leftovers. Their use can be promising approach for food safety for humans without challenging the animal welfare. Although it is expected for further more experimental studies to fully explore the beneficial effects of OAs as feed additives in diet of chickens and pigs.

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