Conference Paper

The Utilization of Prebiotics, Probiotics, Organic Acids and Antibiotics in Monogastric Animals

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Abstract

The gastrointestinal microbiota is a complex ecosystem made up of a multitude of bacterial species, some of which are potentially pathogenic, while others are considered good for the host. The beneficial microorganisms that live in the hindgut influence gastrointestinal functionality and the host's health in general. Nowadays, many dietary supplements are available to be fed to young farm animals such as broilers, turkeys, piglets and calves in order to improve their intestinal health and growth performance. Despite the fact that non-pharmacological feed additives in general do not reach the efficacy of antibiotics as growth promoters, the proper choice and use of a dietary supplement may improve livestock productivity. Nevertheless, it has to be considered that dietary supplements usually increase the feed price, which means that the cost-benefit ratio of feed additives should always be determined.

Keywords: gastrointestinal microbiota; dietary supplements; livestock productivity.

1. Introduction

The gastrointestinal microbiota is a complex ecosystem made up of a multitude of bacterial species, some of which are potentially pathogenic, while others are considered good for the host [1, 2]. The beneficial microorganisms that live in the hindgut influence gastrointestinal functionality and the host's health in general, in virtue of some principal mechanisms: 1) detoxification of some toxic substances introduced through the diet or newly formed as a result of metabolic processes of the body and of intestinal microbiota [3]; 2) "barrier effect" against the proliferation of potentially pathogenic bacteria and their adhesion to the intestinal mucosa, thanks to occupation of the attack sites of these microorganisms and production of selective antimicrobial substances [4]; 3) uptake of ammonia and amines used as a source of nitrogen to support microbial protein synthesis, with a consequent reduction in the intestinal absorption of these undesirable substances [5]; 4) interaction with the host immune system [6, 7]; 5) production of vitamins [8]. It has been shown that an increase of the beneficial bacteria that reside in the gut is a way to treat various intestinal disorders and maintain host health [9].

The growth promoting effects of introducing antimicrobials in animal diets have been known for decades, since Stokstad and Jukes [10] demonstrated that the presence of tetracyclin residues in poultry feeding increased the growth of the animals. Improved growth performances following the use of antibiotics were then described in turkeys [11], pigs [12], and young ruminants [13]. From that time on the use of antibiotics as growth factors has become widespread. The major benefits derived from the use of subtherapeutic doses of antibiotics in animal feeding include disease prevention, improved feed utilization, and increased growth rate. These effects are more evident in younger, stressed animals [14] and where management and hygiene conditions are worse.

Nowadays, antibiotic resistance is a global health problem. Despite the fact that antibiotic resistance is mainly caused by overuse and inappropriate use of antibiotics in human medicine for nonbacterial infections such as colds and other viral infections as well as inadequate antibiotic stewardship by clinicians [15], the relationship of drug-resistant bacteria in people to antibiotic use in farm animals is the subject of scientific discussions and political decisions. In fact, the concerns about the spreading of antibiotic resistance culminated, as of January 1, 2006, in a ban of the use of antibiotic growth promoters within the European Union. Therefore, non-pharmaceutical feed additives must be sought to control microbial activity in the gastrointestinal tract of young farm animals. Among alternatives are prebiotics, probiotics, and organic acids

2. Prebiotics

According to a recent definition, a prebiotic is "a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well-being and health" [16]. Prebiotics are non-digestible carbohydrates, mainly oligosaccharides (NDO) with a low degree of polymerization, obtained by extraction from vegetable raw materials, by enzymatic synthesis or by partial enzymatic hydrolysis of oligosaccharides and polysaccharides. Recent research has indicated that prebiotics can provide a competitive advantage to specific members of the native microflora (e.g., bifidobacteria and lactobacilli) that are known to act antagonistically against pathogens [17]. Prebiotics may reduce intestinal concentrations of ammonia, as increased fermentation leads to higher amounts of nitrogen converted into bacterial protein [18], and biogenic amines [19]. Finally, inulin and fructo-oligosaccharides (FOS) may positively modulate activity of the immune system [20].

When added to diets for broilers in order to improve animal growth performances, prebiotics such as fructo-oligosaccharides (FOS) led to inconsistent and sometimes conflicting results [21–24]. However, beneficial effects of prebiotics on chicken gut health were observed by several authors [25, 26] suggesting that utilization of prebiotic substances may lead to reduced incidence of intestinal bacterial disease. Similarly, when fed to pigs, galacto-oligosaccharides [27] and FOS [5] increased bifidobacteria and reduced the presence of intestinal pathogens. Finally, modulation of intestinal microbiota by prebiotics was observed also in calves [28].

As a drawback to the use of prebiotics, it must be considered that high levels of dietary NDO may result in gastrointestinal bloating, pain, and reduced feed intake. Despite the positive influence that NDO can have on animal intestinal health, there is still a lack of evidence that prebiotics can significantly improve animal growth performance.

3. Probiotics

A probiotic has been defined as a "live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance" [29]. The efficacy of probiotics is influenced by many factors, including their metabolism and ability to survive along the gastrointestinal tract; moreover, type of probiotic used (mainly live bacteria and yeasts), dose, timing and length of administration are all factors that affect efficacy of probiotic treatment [30]. Probiotics can reduce the presence of pathogens in the animal intestine by producing short-chain fatty acids [31], antimicrobial peptides [32] and enzymes that hydrolyze bacterial toxins [33], and competing with pathogens for the same nutrients and sites of adhesion [4]. Moreover, probiotics may enhance the animal immune response [35].

In poultry, administration of probiotic strains may result in protection against intestinal pathogens such as Salmonella [36, 37], improvement of growth performance [23, 38, 39] and egg production [40], and enhancement of the immune system [42]. Feeding a combination of a Lactobacillus spp. strain and lactose improved growth performance of turkeys challenged with Salmonella [42] but in another study [43] the combination of a Lactobacillus acidophilus strain and lactose did not reduce the presence of Salmonella in the crop of turkeys.

Despite the relatively high number of studies that showed benefits from the administration of probiotics to poultry, effects of probiotics on growth performance of broiler are contradictory [44, 45]. Similarly, contradictory results were obtained when probiotic strains were fed to pigs [46, 47] and calves [28]. A possible reason for these discrepancies may be that utilization of probiotics in farm animals is problematic as loss of probiotic viability may occur as a consequence of environmental factors and feed processing techniques.

4. Organic acids

Organic acids are commonly used as food preservatives for their antimicrobial properties. In particular, it is the undissociated form of the acid that can freely diffuse through the membrane of micro-organisms into their cell cytoplasm. Once inside the cell, where pH is close to neutrality, the acid will dissociate and anions will accumulate suppressing cell enzymes (decarboxylases and catalases) and nutrient transport systems [48]. Many factors influence the antibacterial activity of organic acids, including chemical formula and form (acid or salt), pKa of the acid (the pH at which 50% of the acid is dissociated), the micro-organism related MIC-value of the acid, animal species, and feed buffering capacity [49]. With regard to the latter, it has been shown that the inclusion of organic acids in a broiler diet may result in lower pH values of the crop and proventriculus [50].

There is a wide literature regarding the effect of feeding organic acids to broilers on their growth performance and health. Improved growth performances were observed in broilers receiving citric [51], fumaric [52], formic [53], and butyric [54] acids. Among the acids that were tested in weaned pigs, formic, fumaric, and citric acids have been the object of several studies and seem to effectively improve animal growth performance [55]. Other acids that have shown growth-promoting effects include malic, sorbic, lactic [56], and gluconic [57] acids.

5. Conclusions

Nowadays, many dietary supplements are available to be fed to young farm animals such as broilers, turkeys, piglets and calves in order to improve their intestinal health and growth performance. Despite the fact that non-pharmacological feed additives in general do not reach the efficacy of antibiotics as growth promoters, the proper choice and use of a dietary supplement may improve livestock productivity. Nevertheless, it has to be considered that dietary supplements usually increase the feed price, which means that the cost-benefit ratio of feed additives should always be determined.

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