FEED ADDITIVE STRATEGIES TO CONTROL GASTRO-INTESTINAL COLONISATION OF SALMONELLA IN POULTRY

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Summary

Salmonella infections in poultry cause a number of serious problems – impairing bird’s welfare and performance, damaging consumer confidence in the safety of poultry products, distorting public perception of intensive farming and ultimately poultry farmers suffering economic losses. Due to the awareness of the negative impact that pathogenic Salmonella have on the poultry industry, there have been intensive efforts, with assistance from the feed additive industry, to search for natural, cheap and effective products to control Salmonella. Without doubt, every nutritionist and poultry farmer is aware of the products and technologies being developed to target Salmonella contamination. To date, the possibilities include vaccination, feed additives such as antibiotics, possible dietary alternatives to antibiotics; for example, organic acids and salts, formaldehyde, essential oils and specific carbohydrates (lactose, mannose, glucose and fructooligosaccharide). Unfortunately, time and space does not allow this paper to cover all feed additives, their application concepts and mode of actions on the future of the poultry industry. However, those feed additives, which are most used or most likely to make a significant, positive impact on the poultry industry, will be addressed here. As the public become increasingly aware of food safety and health issues there is no room for complacency in the ongoing battle against Salmonella.

I. SALMONELLA INFECTIONS IN POULTRY

Salmonella was named after the United States Department of Agriculture veterinarian, Daniel E Salmon. More than 2,500 Salmonella serotypes have been indentified in nature. Salmonella serotypes can grow at temperatures ranging from 7 to 47 °C, and at pH values of between 4.0 and 9.5. Optimal growth condition is between 35 – 37 °C and pH 7.0 - 7.5. They are easily destroyed by heating. The minimum water activity value for growth is 0.96, but the organism can survive for few months in foods containing fats and at low water activities.

Salmonella infections in poultry can be divided into host specific infections and non-host specific infections. For instance, Salmonella pullorum and Salmonella gallinarum are highly adapted to the host species and are of little public health concern. Infections with paratyphoid Salmonella are non-host specific, the paratyphoid serotype includes Salmonella enteritidis and Salmonella typhimurium (Rabsch et al., 2002). These are capable of causing Salmonella food poisoning in humans. Paratyphoid Salmonella infections in poultry can impair bird’s welfare and performance, damage consumer confidence in the safety of poultry products and distort public perception of intensive farming; and ultimately, poultry farmers suffer economic losses.

II. FEED ADDITIVES USED TO CONTROL SALMONELLA CONTAMINATION

Contamination of poultry by Salmonella is multi-factorial, as contamination might be due to contaminated feed and water, environmental sources and transmission from contaminated eggs. It is difficult to find information on the relative importance of one factor compared with

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another. The bottom line is every factor should not be over-looked as any negligence will increase the prevalence of contamination and will aid in amplifying the potential risk of food-borne illness.

Feed is considered as a potential source for Salmonella contamination of poultry flocks. Although the industry is monitoring Salmonella contamination levels in raw materials, the lack of consistent measures (national or international standard) to prevent Salmonella-contaminated feed being fed to poultry might contribute to the lingering risk in the poultry primary industry (FSANZ, 2006).

To some extent, the heat treatment applied during the pelleting is effective at lowering Salmonella to safe levels, but this is not the case when contamination levels are high. Even if freshly prepared compound feed had low levels of Salmonella contamination, severe recontamination might occur during the storage or transport process (Wierupa et al., 1995); Salmonella might enter the poultry farm via drinking water, dust mites, rodents and wild birds etc, and the situation can be more complicated in free-range farming system. Practically speaking, even if the smallest amount of Salmonella passes to the bird’s GI system and the Salmonella count in any infected faeces will escalate rapidly. Therefore, the preferred product should be used in conjunction with heat treatment in order to protect the feed from contamination and recontamination. In other words, the product should work continuously from the feed mill to the gastrointestinal tract of the bird.

Antibiotics – Use of growth promoting antibiotics has been associated with an increase in resistance of bacteria to therapeutic agents; and a fear that this could reduce the ability to treat diseased humans (McEwen, 2006). This has caused an increased awareness of the use of antibiotics and a general wish to reduce the use of antibiotic growth promoters. For instance, the European Union has totally banned antibiotics use in animal feed since 2006. In Asia, there are currently no antibiotics registered for growth promotion in Japan. South Korea is to ban the use of certain antibiotics in poultry feed in 2009. It is understood that the Australian poultry industry still uses specific antibiotics for growth promotion and improvement of feed utilisation (JETACAR, 1999).

Formaldehyde (CH$_2$O) – Historically, formaldehyde has been used as a feed additive to protect dietary protein in ruminant (Madsen, 1982). In poultry, formaldehyde fumigation is widely used to minimise bacterial contamination of eggs and hatching chicks of to destroy potential pathogenic contaminations. In one case, formaldehyde fumigation increased the severity of mould infection rather than reducing it (Wright et al., 1961). In 1996, US Food and Drug Administration (FDA) stated that formaldehyde, at the dose rate of 0.9 kg per ton, maintained complete poultry feed Salmonella free for about 14 days and FDA also concluded 0.9 kg per ton is safe to use in poultry feed. Based on one tolerance study on fattening broilers, the EU Panel on Additives and Products of Substances used in Animal Feed (FEEDAP) concluded that formaldehyde, at a dose rate up to 0.99 kg/ton, had no effect on feed intake and body weight during the entire experimental period; however, the study also found 0.99 kg/ton inclusion rate significantly reduced feed conversion ratio compared to that of controlled chickens (EFSA, 2004). Some researchers also proposed that formaldehyde can be used to control Salmonella contamination in poultry feed (Brown, 1996; Khan et al., 2006; Summers, 1985). Babar et al. (2001) reported that formalin (37% formaldehyde), at dose rate of 10 g/kg, fed to broiler birds decreased feed intake and body weight. Zulkifli et al. (1999) studied the effect of formaldehyde fumigation during hatching on the performance and behaviour of hatched chicks. This study found that formaldehyde fumigation resulted in overall lower feed conversion ratio, but the birds’ behaviour, bodyweight and mortality rate were not affected by formaldehyde fumigation.

From the metabolic standpoint, formaldehyde is involved in several metabolic reactions in the body. The oxidation into formic acid and carbon dioxide, the reaction with
glutathione, and also the reaction with proteins and nucleic acids, which are partly reversible, are of importance (Kitchens et al., 1976). Since formaldehyde reacts with lysine and other amino acids (Broderick and Lane, 1978), the nutritive value of protein treated with formaldehyde might be reduced. Formaldehyde is highly corrosive and volatile, has a pungent smell, strongly irritates the mucous membrane and has a toxic potential. Therefore, there are concerns about the palatability of treated feed, efficacy on performance of birds and possible adverse health considerations resulting from inhalation of formaldehyde fumes. Formaldehyde is either banned or not used at all in the EU, Japan and NZ.

Organic acids/salts/esters – Short chain fatty acids and salts (Hinton and Linton 1988) (AL-Tarazi and Alshawabkeh, 2003; Heres et al., 2004; Van Deun et al., 2008); medium chain fatty acids (Skrivanova et al., 2006; Van Immerseel et al., 2004) and esters (Thormar et al., 2006) have been widely evaluated for their usefulness in manipulating intestinal biochemistry to either directly kill or inhibit Salmonella and campylobacter colonisation and to support the growth of protective bifidobacteria and lactobacilli bacteria (Dibner and Buttin, 2002; Owens et al., 2008).

Apart from being particularly effective against acid-intolerant Salmonella, Campylobacter or E. coli, feeding organic acids can also improve nutrients (protein and energy) digestibility, reduce the digesta pH, increase pancreatic secretion and trophic effect on the gut mucosa. Hence, the application of organic acids in poultry feed or drinking water enhance the bird performance (Abdel-Fattah et al., 2008; Byrd et al., 2001; Dibner and Buttin, 2002; Viola et al., 2008).

From a review of the literature for poultry, there is a lack of consistency in demonstrating organic acid benefits in animal performance (Dibner and Buttin, 2002). Several factors influencing responses to organic acids have been identified. Briefly, the efficacy of the antimicrobial effects varies from one acid to another and is dependent on concentration of the acid applied, the level of contamination and buffering capacity of the diet, pH of the gastrointestinal tract (Chaveerach et al., 2002; Salsali et al., 2006) and animal factors such as stress and a low threshold level of tolerance against pathogenic bacteria from feed (Burkholder et al., 2008). Therefore, further research is needed to specify the interaction between these factors and different organic acids.

Given different countries have different legislations towards the use of antibiotics or feed additives, application of different additives needs more detailed scenarios of pathogens response and host-pathogen interaction under different environmental conditions. Gathering this detailed information should yield clues for developing new products to better exploit vulnerabilities of food borne Salmonella during feed processing and application of feed additives.

III. CONCLUSION

From the practical point of view, the most efficient way for Salmonella control should be the combination of monitoring, biosecurity, vaccination and using the correct feed additive. All feed additives used for Salmonella control have pros and cons. To produce Salmonella-free products, one needs to consider not only the efficacy of the product, but also the long-term rewards.

REFERENCES


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