Role of Vaccination in the Control of Poultry Salmonellosis

Introduction
According to the Centers for Disease Control and Prevention (CDC), salmonella infections remain as one of the major causes of human food poisoning in the U.S.

Domestic poultry constitutes one of the main reservoirs for salmonella infections in humans.

Even though the farm environment is a rich source of a wide number of Salmonella serotypes, S. Enteritidis exhibits a unique ability to contaminate eggs and cause human infections. Human infections with S. Enteritidis involve bacterial colonization, survival and multiplication in the hen house environment, the bird and finally the egg.

The constant risk of human infections has been a determinant factor in the development and implementation of quality assurance programs directed to guarantee the safety of eggs for human consumption. Furthermore, vaccination programs against S. Enteritidis have been widely implemented to provide a last line of defense in the bird against infection by field strains.

Salmonella classification
In poultry, two main categories of salmonella infections are present. In the first category, we find the avian-adapted S. pullorum and S. gallinarum, which cause pullorum and fowl typhoid diseases, respectively. These salmonella serotypes have caused severe economic losses to the poultry industry in the past and have been addressed by the implementation of extensive testing and eradication programs.

The second category group includes the motile salmonella serotypes or paratyphoid (PT) salmonellae. In the PT group, S. Typhimurium and S. Enteritidis show an outstanding ability to colonize the alimentary tracts of poultry and cause food borne diseases in humans (Zhang-Barger, 1999). S. Enteritidis outbreaks in humans have been associated with the consumption of contaminated or undercooked poultry products, such as eggs and egg-containing products. As a consequence, poultry producers are constantly under pressure from public health authorities and consumer organizations regarding food safety of poultry products.

Some strains of S. Typhimurium and S. Enteritidis are capable of producing clinical disease in young chickens during or after a period of physiological stress. In these cases, a systemic disease involving the reticulo-endothelial system occurs in addition to fecal excretion (Barrow, 2007).
Salmonella infection

The oral route is the natural route of salmonella infections in poultry. After oral infection, the organisms rapidly invade the lymphoid tissue located in the intestinal tract (Peyer’s patches and cecal tonsils) and probably the enterocytes of the intestinal mucosa. Finally, the organisms gets into the blood stream, probably intracellularly, reaching the spleen, liver and bone marrow (Gast, 2003).

Infection of newly hatched chicks results in a massive multiplication of salmonella, with large numbers being excreted in the feces for several weeks. Later, after acquisition of a more complex normal microflora, infection results in excretion of fewer bacteria for a shorter period (Zhang-Barger, 1999). PT infections often have a different outcome for very young chickens when compared with mature birds. Young chicks and poults are very susceptible, with illness and death observed at high frequencies (S. Arizonae infections in young turkey poults).

In contrast, older birds are less susceptible to the infection, experiencing intestinal colonization and even systemic dissemination without causing significant morbidity or mortality. This age-related resistance has been attributed to the acquisition of stable microflora, which compete with salmonella receptors in the intestine and/or create metabolic products which inhibit salmonella growth (Gast, 2003).

Salmonella prevention and control

The major obstacles to salmonella control in the poultry industry are the ubiquitous presence of salmonella and the presence of multiple serotypes. Salmonella infection can be introduced into poultry flocks from many different sources, including water, live haul transportation, contaminated feed, biologic vectors (flies, cockroaches, darkling beetles, rodents and mealworms), wild birds and humans. Furthermore, vertical transmission of PT Salmonella from the breeder flocks to the progeny leads to bacterial exposure and dissemination in the flock.

Effective prevention and control programs must involve several simultaneous approaches, such as the incubation of eggs from salmonella-free breeding flocks, adequate cleaning and disinfection of poultry houses, control of rodents and insects, restrictive movement of personnel and equipment between houses, chlorination of drinking water and the use of competitive exclusion. However, due to the prolific nature of salmonella in infected chickens, these efforts will not lead to salmonella-free chickens if the chickens are unable to prevent salmonella proliferation. For such reason, vaccination must be a major component of salmonella control programs, inducing an inherent protective mechanism within chickens that will ensure a low level or elimination of salmonella contamination (Hassan, 1994).

Salmonella vaccines

Inactivated and live vaccines have shown to reduce the susceptibility of poultry to PT infection. Inactivated vaccines, generally administered by subcutaneous injection, stimulate the production of antibodies. Immunoglobulin G (Ig G) antibodies are found in a high concentration in the yolk sac, providing some degree of protection against salmonella contamination of table eggs or infection of the chicken embryo. Subcutaneous administration of oil emulsion inactivated vaccines to pullets has been reported to significantly reduce the frequency of S. Enteritidis isolation from internal organs and fecal shedding (Gast, 1992-1993). In commercial layers, some management practices, such as molting, are implemented to increase the productivity and extend the useful life of the flock. Moulting alters the gut flora in the birds, favoring the shedding of salmonella in the feces and increasing the risk of egg contamination. The use of inactivated vaccines prior to molting has shown to be effective in preventing the exacerbation of S. Enteritidis problems within flocks in which the potential for contamination may exist (Nakamura, 2004).

Live attenuated S. Typhimurium vaccines are commercially available in the U.S. Live attenuated vaccines must be safe for animals and humans, provide protection against mucosal and systemic infections and reduce intestinal, environmental and egg contamination (Barrow, 2007). Live attenuated salmonella vaccines have been associated with a more diverse protective immune response in poultry when compared with inactivated vaccines (Barrow, 1990). Furthermore, if administered orally, live vaccines have demonstrated non-specific and rapid protection against salmonella infection (Barrow, 2007). Additional advantages related with the use of live attenuated vaccines are the in vivo expression of all appropriate antigens in vivo, the easier massive administration via drinking water or coarse spray and the stimulation of the cell-mediated immunity (CMI). CMI has been associated with salmonella clearance from the internal organs, reducing the shedding of salmonella in the flock’s environment. Vaccine-induced protection against infection involves both cell mediated and humoral responses, the latter in the later stages of infection (Mastreoeni, 2003).
Live attenuated vaccines have been produced by successive passages in low nutritional medium or by genetic deletions of some specific genes (i.e. aroA, cya and/or crp) associated with bacterial growth, which are present in the natural salmonella wild types (Hassan, 1994). Since genetically modified salmonella cannot reverse to their wild type, gene deletions have been used in monitoring programs to differentiate vaccine from field isolates. Genetic or metabolic drift mutations in live vaccine strains adversely affect essential enzymes or metabolic pathways, resulting in reduced bacterial growth and virulence while still remaining immunogenic (Linde, 1997).

Experimental S. Typhimurium and S. Enteritidis infections in young poultry have consistently showed that newly hatched birds are highly susceptible to salmonella, with susceptibility decreasing over time. This age-related resistance seems to be associated with the presence of competing bacterial flora in the intestinal tract of adult birds that makes it hard for pathogenic salmonella to colonize the intestine. In commercial layers and broiler breeders, susceptibility to infection increases again dramatically as the young pullets begin to come into lay and in commercial layers when the hens are put into mold. When live attenuated vaccines are administered to newly hatched chicks, they multiply extensively because of the absence of the complex normal microbial flora found in adult birds and the immaturity of their immune system (Berchieri, 1990; Cooper, 1994). The early multiplication of salmonella organisms present in the live attenuated vaccines prevents the colonization of other salmonella strains (field strains) due to the limited carbon sources and electron acceptors present in the intestinal tissue (Zhang-Barger, 1997). The practical consequences are that administration of live vaccines in very young chickens by drinking water or coarse spray would give protection within hours against invasion of other salmonella organisms. This rapid protection by a colonization-inhibition effect would be followed by the development of normal immunity within a couple of weeks.

Summary

Salmonella enterica serovar Enteritidis still remains as a major political issue affecting the poultry industry due to its unique capacity to contaminate table eggs and other poultry products and to cause disease in humans. Since salmonella infections can be introduced in susceptible flocks through numerous sources, strict biosecurity and quality assurance programs should be implemented. However, due to its ubiquitous presence and constant risk of contamination, vaccination programs must be considered as an additional and very important practice to prevent colonization of susceptible birds with S. Enteritidis in the field.

References


Over the last decade, Lohmann Animal Health has led the way in Salmonella vaccine development.

More than 10 years of research in both live and killed Salmonella vaccines have made Lohmann the worldwide leader in this field. Our Germany headquarters has made major inroads in the battle against Salmonella with AviPro® Salmonella Vac E.

Lohmann Animal Health in Maine introduced gene modified Megan®Vac 1 and Megan®Egg for protection against Salmonella typhimurium, Salmonella enteritidis and Salmonella heidelberg. These mass-applied live vaccines are used in pullet and broiler programs in the U.S. and international markets.


You can count on Lohmann Animal Health and our technical groups to help you solve your Salmonella problems.

Let us share our expertise with you. Come by our booth, No. 4748, in Exhibit Hall B at the International Poultry Expo in Atlanta in January and let us tell you about our complete line of breeder vaccines.