Sweet harmony – preventing salmonella in table eggs

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When researchers in Australia found a dead Gecko between the inner shell and the membrane they euphorically announced that they discovered how salmonella gets into the egg. This might be the case in Northern Australia; however, Geckos are not a common feature on many commercial layer farms.

It is more likely that contamination of eggs with Salmonella spp. occurs by penetration of the organism through the shell or by transovarian infection.

Investigations in the USA by the Centre for Disease Control (CDC) in 1986/1987 and 1998-2001 showed that eggs or foods containing egg were implicated in over 70% of all salmonella outbreaks in humans. The cost associated with salmonella to the US economy alone is estimated at US $966 million in direct and indirect costs.

Although there is a general decline in the number of reports of eggs infected with salmonella there remains a very large variability between egg producers across different countries.

A survey in the EU by the European Food Safety Authority found that in some countries the incidences of salmonella on layer farms measured in dust, bird faeces or other material is over 70%.

Sources of salmonella

The potential sources of salmonella on an egg farm are variable and reach beyond the simple control of salmonella in feed or water.

For example, it was found that common house flies present a potential risk to the spread of salmonella. Hens do not get infected by simply being around infected flies; however hens can contract salmonella when they eat an infected fly.

Other potential sources include infection of pullets from breeder flocks, rodents, wild birds or inadequate biosecurity and subsequent transmission through humans.

Although salmonella on farm is not necessarily related to the incidences of salmonella in eggs these numbers are extremely alarming. Contamination of eggs with salmonella represents a major public health risk.

It is therefore not surprising that authorities in the EU have set the level of mandatory vaccination of all laying hens in cases with a salmonella prevalence of 10% or more.

The control of salmonella in table eggs is an issue well beyond the borders of the EU not only because of the increases in the global trade of food.

Other regions implement routine bacterial monitoring and reject shipments that do not meet set criteria.

There are over 2,500 different serotypes of Salmonella enterica. However, only a number of these serovars will cause disease in humans. For example S. pullorum or S. gallinarum are two poultry adopted salmonella strains which can cause high morbidity and mortality in egg layers, but rarely cause disease in humans.

On the other hand, S. typhimurium or S. enteritidis can be carried by poultry with little or no clinical signs but these two serotypes are most commonly associated with human infections.

Due to the lack of disease symptoms and the benign nature of salmonella in layers, identification and specific control of infection is difficult. Both these serovars can persist in the ovary and oviducts of hens and infect eggs directly (vertical transmission).

Although vertical transmission does occur the most common way of contamination of eggs is horizontal transmission from a contaminated environment.

Legislation is focusing on the monitoring and the control of these two serovars. In fact the EU have set a target of complete absence of S. enteritidis and S. typhimurium in 25g of fresh eggs by 2011.

Reducing the risk

Refrigeration of eggs is crucial to prevent the multiplication of salmonella inside the egg. The effectiveness of refrigeration depends on the location of salmonella inside the egg and the actual refrigeration temperature.

Proteins in the egg albumin prevent the rapid growth of salmonella in the egg albumin, however salmonella present in the nutrient rich yolk could rapidly multiply.

Extensive multiplication can be prevented by storage below 20°C, although most quality assurance programmes require refrigeration at 7.2°C during storage.

A general recommendation to prevent the transmission of salmonella from eggs to

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humans is to cook, wash or pasteurise eggs or egg products. The reduction of salmonella varies widely depending on the actual cooking method.

For example, it was shown that cooking contaminated eggs using the 'sunny side up' method (endpoint cooking temperature 58.9°C) or free poached method (endpoint cooking temperature 48.4°C) resulted in salmonella positive samples after cooking.

Egg washing is another tool to reduce the risk of shell contamination with salmonella. While the practise of egg washing is not without controversy, in the US it is common practise to wash eggs with an approved detergent and disinfectant, whereas the EU prohibits the washing of Class A eggs to protect the natural defences of the egg, the cuticle.

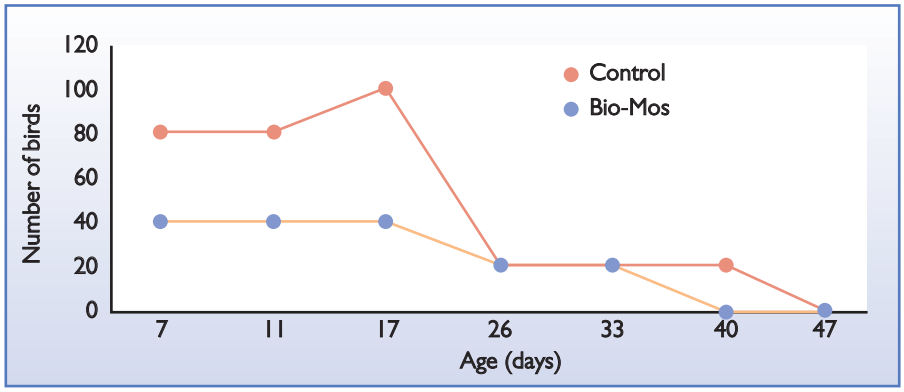

Fig. 1. Number of birds tested positive for caecal salmonella infection fed Bio-Mos compared to an unsupplemented control.

Developments in pasteurisation methods and the use of microwave technology or ionising radiation could also be effective tools to reduce salmonella in shell eggs.

There are question marks on the widespread use of these technologies due to consumer concerns on food safety as well as some concerns on their impact on egg quality and nutritional parameters.

Control on farm

The most important point to reduce salmonella on layer farms is biosecurity, which includes control of movement of people and equipment on farm and between farms, effective rodent, insect and wild bird control programmes and the supply of clean water and decontaminated feed.

With the upcoming ban on conventional cages for laying hens in the EU by 2012 there is increased interest on the effects of different housing systems on bacterial contamination of eggs.

Overall findings would indicate that differences in eggshell contamination between housing systems are variable and not significantly different; however some reports found that eggs produced in conventional cages have a tendency for higher prevalence of salmonella in comparison with enriched cages or aviaries.

A widely used tool to control salmonella on farms is the use of vaccine with the aim to prevent systemic infection in the reproductive tract as well as reduce the faecal shedding of salmonella.

The use of vaccines in layer flocks is not without controversy, for example when

Table 1. Salmonella detection at sacrifice (bird/grou

Group	Wild-type salmonella detected by cloacal swab (birds/group)
Control	11/50
Bio-Mos	10/50

using a salmonella vaccine it gets more difficult to effectively monitor wild-type salmonella infections since serological tests are unable to differentiate between antibody titres induced by vaccine or wild strains.

Furthermore, the widespread use of vaccine can interfere with a successful eradication programme for salmonella.

Use of feed additives

Heat treatment is the most commonly used method to eliminate salmonella in feed. Pelleting at temperatures above 85°C for two minutes or the use of expansion or extrusion systems are generally regarded as sufficient to decontaminate feed.

These measures are very common for broiler feed, however commercial layer diets are generally not pelleted and other avenues such as the use of technical feed ingredients can be used as a valuable tool of control.

Specialist mannose-rich yeast cell wall material derived from primary grown yeast, such as Bio-Mos from Alltech Inc, effectively binds several major strains of salmonella.

Since the 1960s it has been known that salmonella attach to the intestine by using carbohydrate (lectins) projections on their surface. Once attached bacteria can multiply and colonise the host and potentially invade the ovary and oviducts.

In addition, rapid multiplication in the intestine will lead to increased shedding of salmonella in the faeces, which is a further risk of spreading salmonella.

Many of the lectins that are found on salmonella associated with human disease attach to mannose structures. In vitro studies have shown that 80% of Salmonella typhimurium and 67% of Salmonella enteritidis express mannose sensitive fimbriae and adding yeast derived mannanoligosaccharides (MOS) to the diets blocks the bacterial attachment and therefore reduces colonisation by pathogens (Fig.1).

The selective nature of the binding capacity of MOS means that the beneficial bacteria in the intestine are not affected. In fact further research has shown that adding MOS to a diet will increase the relative abundance and the prevalence of lactobacilli as well as enrich the diversity of lactobacilli phylotypes.

When improving the growing condition in the intestine for beneficial bacteria it prevents potential pathogens such as salmonella from establishing themselves.

Further research demonstrated the protective effect of MOS against salmonella challenge.

Work from the Czech Research Institute showed that the number of birds infected naturally at the hatchery and challenged with a nalidixic acid resistant strain of S. enteritidis had 75% fewer caecal infections and 66% fewer organ infections compared to the control group (Table 1).

Conclusions

Controlling salmonella infections in eggs is a major focus for egg producers globally. Increased media focus and the introduction of legislation in many countries which demands low incidences of salmonella in layer flocks puts pressure on producers to have strict salmonella control programmes in place.

It has now been shown that in addition to strict biosecurity programmes the use of technical feed ingredients in the form of Bio-Mos (a mannan-oligosaccharide derived from primary grown yeast cell wall) have the potential to bind the salmonella strain which can potentially cause illness in humans.

The efficacy of Bio-Mos to reduce the vertical transmission as well as the horizontal transmission has been proven in many trials, and can be an effective tool to reduce the prevalence of salmonella in eggs. ■

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Wild type strain (Novobiocin)	Experimental strain (Nalidixic acid)
Caecum 38/50 Organs 42/50	Caecum 6/50 Organs 6/50
Caecum 9/50 Organs 14/50	Caecum 0/50 Organs 0/50