Egg Safety

Control Factors of Salmonellosis

By

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Introduction

Salmonella enterica serotype Enteritidis (SE) continues to be one of the most commonly identified bacteria associated with outbreaks of human salmonellosis around the world, particularly in developed countries (CDC, 2011). In the United States, salmonellosis is a common infection with occurrences reaching up to 1.4 million in a year (Braden, 2006). From May to November of 2010, approximately 1,983 illnesses were reported and associated as a result of a single *Salmonella spp* outbreak detected in the United States (CDC, 2011). The source of the outbreak was traced to Wright County Egg in Galt, Iowa and subsequently led to the voluntary recall of 380 million eggs distributed throughout the country. Hillandale Farms, also in Iowa, voluntarily recalled another 170 million eggs (CDC, 2011). Identifying the source of the outbreak was the result of coordinated investigations by the Center for Disease Control (CDC), local public health authorities and the Food and Drug Association (FDA).

Salmonellosis outbreaks in the United Kingdom began occurring with such frequency that a control program was implemented in 1986. The current control program has been in effect since 1993. Reports of SE outbreaks in the UK decreased from 33,000 in 1997 to 16,465 in 2001. This decrease has been attributed to several factors, including codes of conduct for hygiene and increased testing regulations (Cogan and Humphrey, 2003). Additionally, voluntary participation in the British Egg Industry Council Lion Code of Practice requires the use of vaccines for laying hens to increase public health (see Appendix A) (Cogan and Humphrey, 2003).

According to the United Egg Producer's (UEP) website, the chance of eggs containing SE is rare in the United States. Estimates are 1 in 20,000 eggs might be contaminated with SE

(UEP, 2010; Guard-Petter, 2001). This would mean that a consumer would encounter an infected egg once in 84 years. The number is also claimed to be decreasing due to the increased protection measures adapted by egg producers over the past decade. Improved sanitary housing systems, vaccinations and cleaning processes have all led to the claim of decreased cases of SE throughout the nation (Braden, 2006; UEP, 2010; Patrick, et al., 2004). The use of average outbreaks can be misleading due to the nature of infection and their correlation to single producer outbreaks. Investigation into SE outbreaks between 1985 and 1999 by Patrick, et al., 2004 concluded that outbreaks of SE infections in human decreased by almost 50% between 1995 and 1999. These reports may have left people feeling like things were on the right track, then the Wright County Egg incident occurred. Without constant vigilance and willingness to incorporate new ideas, the next big outbreak is around the corner. This paper will look at the various methods available to increase the quality of eggs and integrating those ideas into a viable program to fortify public safety.

Salmonella Bacteria

The genus *Salmonella* is in the family Enterobacteriaceae and consists of two species: *Salmonella enterica and S. bongori*. *S. enterica* also has been further divided into six subspecies with over 2,400 known serovars (CDC, 2011, Gast, 2007). Any of these serotypes can cause gastrointestinal illness to some extent in humans (CDC, 2011; Forshell and Wierup, 2006). However, *Salmonella enterica* serotype Enteritidis (SE) has been identified as the cause for major salmonellosis outbreaks involving shell egg consumption and is the major focus of control programs (Table 1) (Braden, 2006; Forshell and Wierup, 2006; Kotz, 2010; Patrick, et al., 2004).

Additional outbreaks of human salmonellosis from egg consumption have come from *Salmonella enterica* serotype Typhimurium (ST) but occur with less frequency (Gantois, et al., 2009).

Table 1. Number and incidence of laboratory confirmed Salmonella infections caused by the top 10 Salmonella serotypes, preliminary data for 2009 in the United States (CDC, 2011). Original data from FoodNet, United States.

Salmonella serotype	Number of cases	Incidence per 100,000 population
Enteritidis	1226	2.64
Typhimurium	1024	2.21
Newport	772	1.67
Javiana	544	1.17
Heidelberg	230	0.50
Montevideo	206	0.44
I 4, [5], 12:i:-	197	0.43
Muenchen	170	0.37
Saintpaul	157	0.34
Oranienburg	132	0.28

Salmonella bacteria are found in the intestinal tracts of mammals, birds, reptiles and insects. *Salmonellae* are rod-shaped, facultative anaerobe, flagellated, gram-negative bacteria. The bacterium is ingested orally through contaminated food or water sources. Refrigeration can prevent continued growth, but does not kill bacteria. *Salmonella spp* are destroyed by heat; heating at 57-60ºC or 134-140ºF effectively kills the bacteria. *Salmonella spp* can be found on the outside of an egg shell before washing or can be inside the egg from an infected hen. Federal regulations require that all eggs from commercial producers be sanitized prior to packaging (CDC, 2011; USDA, 2011).

SE outbreaks have been attributed to undercooked eggs or foods containing undercooked eggs served in homes, private gatherings, commercial establishments such as restaurants, hospitals, nursing homes and schools. Persons infected with SE microorganisms may experience diarrhea, fever, abdominal cramps, headache, nausea and vomiting. The incubation period for SE is 8-48 hours. There is an illness duration period of 3-7 days for the gastro-intestinal symptoms and 72 hours for the fever. A stool culture will remain positive for 4-5 weeks. Children, the elderly and persons with weakened immune systems may develop severe or even life-threatening illness (CDC, 2011).

Transmission

Salmonella spp enter the poultry egg through one of two methods, internal contamination or on the outer shell surface (Gantois, et al., 2009; Holt, et al., 2010). Internal contamination can be the result of penetration through the eggshell or by direct contamination of egg contents before oviposition, originating from infection of the reproductive organs. Once inside the egg, the bacteria need to cope with antimicrobial factors in the albumen and vitelline membrane before migration to the yolk can occur (Gantois, et al., 2009). Current research suggests that contamination of the eggs is primarily due to passage of the bacteria from the hen's intestinal tract to the reproductive tract with subsequent incorporation into the forming egg. Although several different *Salmonella* serotypes can pass from a hen's blood stream to the reproductive tract, SE appears to be the one serotype that has the capacity to survive antimicrobial attacks during egg formation within the hen's oviduct (Gantois, et al., 2009; Gast, 2007; Keller, et al., 1995).

External contamination of egg shells can come from the hen's environment and vectors such as rodents. *Salmonella spp* exposure from environmental factors should be minimized to increase biosafety. Sanitation and inspection controls of egg production and packaging have led to a decrease in the number of eggs contaminated through the outer shell (Holt, et al., 2010; Patrick, et al., 2004). Several regulations are in place to minimize the cross-contamination of poultry housing units and more are being proposed for production flocks with over 5,000 hens (CDC, 2011). Several other post-harvest cross contamination minimization efforts include ultraviolet light technology, microwave technology, pulsed light technology, ultrasounds, and others (Galis, et al., 2013).

Detection

An egg contaminated with *Salmonella* bacteria cannot be distinguished from a non-contaminated egg through physical or visual inspection. Detection of SE inside an egg is determined effectively through the use of serologic and bacteriologic testing methods (Wegener, et al., 2003). These testing methods can be complicated by the use of live vaccines for SE which would create cross-reaction issues in the testing process (Wegener, et al., 2003).

The inherent problem with detecting SE in eggs through physical inspection is equaled in the inability to detect an infected hen. SE infection of layer flocks does not cause mortality and can go unnoticed in the hens. It is also difficult to utilize egg sampling to determine SE-positive eggs as this monitoring method has led to low detection numbers (Holt, et al., 2010). Currently, federal regulations are in place to determine sources of outbreaks through increased reports of illness and tracing back to infected flocks. If people do not report their illness, this system cannot determine the outbreak has happened. The use of trace back techniques in the US, allows human illness to occur prior to any action being taken to eradicate the spread of the disease. Human health benefits can have increased effectiveness through the pre-harvest measures including the use of egg and hen monitoring along with improved hygiene practices (Mumma et al., 2004; Wegener et al., 2003).

Current US Regulation and Process

Under FDA's *Prevention of Salmonella Enteritidis in Shell Eggs During Production, Storage, and Transportation* final rule, the pallet, case, or other shipping container must be labeled and all documents accompanying the shipment must contain the following statement: "Federal law requires that these eggs must be treated to achieve at least a 5-log destruction of *Salmonella enteritidis* or processed as egg products in accordance with the Egg Products Inspection Act, 21 CFR 118.6(f)." The statement must be legible and conspicuous.

Official egg products plants need to maintain daily records sufficient to document the implementation and monitoring of their control procedures for the segregation, processing, and sampling of egg products manufactured from recalled shell eggs. Plant records should include all shipping records accompanying any shipments of recalled shell eggs. Under 590.200(a), official egg products plants that receive any eggs in commerce must maintain records showing the receipt, delivery, sale, movement, and disposition of all eggs they handle. Under 590.200(b), they must maintain production records by categories of eggs, bills of sale, inventories, receipts, shipments, names and addresses of shippers and receivers, and dates of shipment and receipt. This includes the amount of eggs received and the date they were received.

Controlling US Agencies

There is a different agency responsible for shell egg production and shell egg products. This alone creates a confusing and often misleading representation of which government agency does what and when. FDA and FSIS share federal regulatory responsibility for egg safety, with the regulation of shell eggs primarily the responsibility of FDA. Currently, the FDA is primarily responsible for shell egg production and recalls. Once the shell egg has been processed, either through pasteurization or use in another product, the USDA FSIS becomes responsible for public health and safety. The Wright County egg recall of 2010 was the largest such egg recall in recent history due to SE. Most of the safety recalls related to *Salmonella spp* have involved other agricultural products such as spinach and peanut products. There has been an increase in reporting of events related to SE over the past 10 years but the number of human illness cases may actually have been decreasing (Kotz, 2010; Patrick, et al., 2004).

History of US inspections

The Egg Products Inspection Act (EPIA) was enacted in 1971 to deal specifically with situations, such as the Wright County Egg recall, where health hazards are potentially identified by certain qualities of shell eggs. Under the EPIA, FSIS regulates the processing and distribution of shell eggs and egg products by prohibiting or limiting the use of certain categories of shell eggs that could pose a risk to public health. Therefore, all shell eggs affected by the recall that are diverted to official egg products plants should undergo normal processing. FSIS inspection program personnel are to verify that the plant has established controls to ensure that any egg product produced using shell eggs suspected of containing SE are segregated, pasteurized, and tested to ensure that the finished egg product is *Salmonella spp* negative.

US Federal Controls

FSIS implemented a system called the Public Health Information System (PHIS) in efforts to increase their ability to collect, consolidate, and analyze data. This is a fully automated data-driven inspection system that covers four aspects: domestic inspection, import activities, export activities, and predictive analytics (USDA, 2011). This system is in response to the President's Food Safety Working Group guidelines to develop a modern, coordinated food safety system in order to prevent harm to consumers. The underlying reasons for such a system are to identify and quickly stop outbreaks of foodborne illness.

The web-based system is designed to integrate all data sources to increase the quality of reporting and management of information. FSIS will be able to coordinate effectively with stakeholders and other agencies to improve investigations and contamination tracing. PHIS will provide accurate information to FSIS personnel in order to increase their ability to identify deficiencies in process controls and to anticipate developing problems.

Through the use of multiple data sources, PHIS creates informational data-bases from which analysts are able to identify trends. Once these trends are identified, the inspections and sampling areas can be adjusted accordingly. For example, the relationship between *Salmonella spp* test results and inspection findings enable inspectors to notify field personnel regarding potential public health threats. Processes for auditing inspection programs of foreign countries exporting meat, poultry and processed egg products to the United States will also be automated.

The automated system covers all functions of the system, including establishment applications for approval for export, applications for export certificates and the issuance of export certificates. PHIS will enable an automated edit-check capability to ensure that certificates properly reflect a foreign country's import requirements.

The PHIS does not create new requirements or regulations for establishments regarding domestic inspection. What it will do is enable inspection personnel to better identify shortcomings in the food safety systems of establishments and anticipate problems before they result in adulterated products entering commerce. The new system will guide in-plant inspection personnel to focus their attention on the specific aspects of an establishment's food safety systems and supporting documentation that have the most significant impact on public health.

In April of 2000, the U.S. Department of Agriculture, FSIS and U.S. Department of Health and Human Services; Food and Drug Administration announced a joint plan to make eggs safer through participation in an Egg Safety Action Plan. This plan was part of President Clinton’s Council on Food Safety to reduce SE in chicken eggs (USDA, 2011). Safe handling instructions that were announced in 1999 were the first attempt to increase consumer safety through a combined effort of both FSIS and FDA.

Under the action plan, FDA develops standards for the egg producer and the states provide oversight and enforcement on the farm; FSIS develops standards for both shell egg packers and egg products processors and provides inspection and enforcement for both; and FDA and the Centers for Disease Control and Prevention conduct surveillance and monitoring activities. CDC will focus on human health and FDA will focus on the food supply (USDA, 2011).

Pre-Harvest Controls

The use of antibiotics in poultry is strictly regulated by the FDA and USDA. The US egg industry uses antibiotics therapeutically to treat an infected flock rather than as a preventative measure for many reasons. Antibiotics, as well as other types of drugs, are required to go through pre- and post-drug approval monitoring, including several types of toxicology and pharmacology studies to access the safety of residual antibiotic in poultry tissues and eggs (UEP, 2000). Egg producers along with their veterinarians are responsible for the handling and distribution of antibiotics used on a poultry farm (Murray, 2000; Holt, et al., 2010; UEP, 2010). Antibiotic resistance can also become a primary factor in the presence of SE on a poultry farm (Manie, et al., 1998; Helmuth, 2000).

Egg Quality Assurance Programs (EQAPs) are voluntary programs designed to minimize transmission of SE and have been adopted in several states (Mumma, et al., 2004). EQAPs can be either state-sponsored or industry-sponsored, but both have the goal of decreasing SE transmission through monitoring flocks through approved methods. Mumma, et al., (2004) evaluated EQAPs procedures and concluded the programs appear to have a major influence on decreasing human health risks from SE illness in the United States. The effect of EQAP interventions were shown to be effective in the first year of implementation and continued five years post-intervention. Flock-based intervention measures, such as intensive rodent control, have the capacity to decrease public health risks and control *Salmonella* in eggs (Mumma, et al., 2004). Monitoring of the flock and the facility helps to identify if the environment is positive for SE. A regular testing of samples from the area such as manure areas, egg belts, and feed can assist in controlling the spread of SE. Once an area has tested positive, all the eggs produced by that flock can be sent for pasteurization or other production method in order to effectively control the spread for the lifetime of the infected flock. Additionally the producer has the option of eliminating the infected flock entirely (Mumma, et al., 2004; Wegener, et al., 2003).

Pennsylvania's Egg Quality Assurance Program (PEQAP) utilized a number of management practices in order to minimize SE transmission in laying flocks (Henzler, et al., 1999). Several egg producers voluntarily participate in the active monitoring of their flocks and eggs. These management practices did not include a vaccine, but rather increased hygiene and testing methods. Results of the monitoring were reported to be a decrease in human cases of *S. enteritidis* isolation rates during the time frame between 1989 and 1997 (Henzler, et al., 1999).

A study of California egg layers and participants in the California Egg Quality Assurance Program (CEQAP) determined flock management influenced the number of SE positive tests (Castellan, et al., 2004). Like most EQAPs, the CEQAP is a voluntary reduction program. The initial results of the study indicate management-related interventions, such as manure removal intervals, can influence SE persistence in the laying hen's environment. Castellan, et al., (2004) state that more study is required to determine a correlation between time intervals of cleaning versus cleaning methods, however, the removal of the manure is an essential step in decreasing SE.

The control programs in Denmark for decreasing incidents of human salmonellosis is vaccination free (Wegener, et al., 2003). According the synopses of Denmark's programs done in 2003, the use of vaccines in chickens cannot be used due to cross-reaction of the serologic testing methods. Monitoring the flock for SE through testing has effectively decreased levels of

SE in commercial laying flocks of Denmark (Wegener, et al., 2003). Control of residual infections is also controlled with the use of cleaning and disinfecting housing areas and cages (Azakura, et al., 2001).

The use of monitoring for SE through intensive flock-level testing in Denmark has been effective in controlling infections. The Danish program established criteria for bacteriological testing and hygiene practices for laying hen flocks. Table 1 indicates the testing methods used by Wegener, et al., 2003. Figure 1 shows a dramatic decrease in the percentage of infected layer flocks between 1998 and 2001, after control programs were introduced. However, this eradication program also came with a cost to the government of $26.5 million, mostly to reimburse farmers for destroyed animals (Wegener, et al., 2003). The estimated societal savings for Denmark during 2001 was $25.5 million (Wegener, et al., 2003).

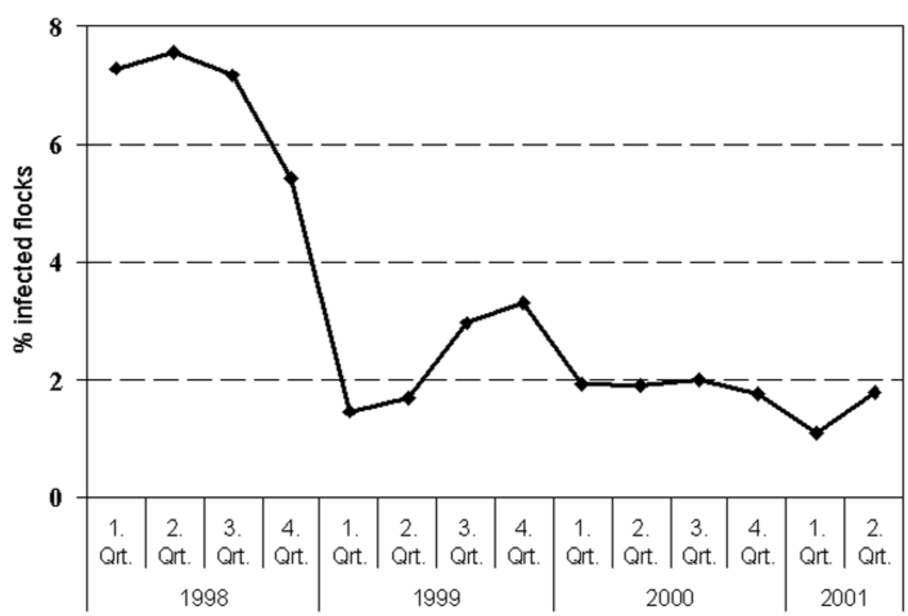

Figure 1. SE in Danish layer flocks as determined by serologic and bacteriologic testing of each commercial flock in week 9 of production. (Wegener, 2003)

Table 2. Salmonella spp surveillance of broiler and egg production, Denmark, 2000 (Wegener, 2003)

Stage of production	Age or frequency	Samples taken	Method
Central rearing stations, broiler and egg sector	Day-old chickens	10 samples of crate material, 20 dead or destroyed chickens(a)	Bacteriologic
	1 wk	40 dead chickens	Bacteriologic
	2 wks	2 pairs of sock samples	Bacteriologic
	4 wks	60 fecal samples(a)	Bacteriologic
	8 wks	2 pairs of sock samples	Bacteriologic
	2 weeks before moving	60 fecal samples and 60 blood samples (ab)	Bacteriologic, serologic
Breeders (hatching egg production)-broiler and egg sector	Every 2 wks Every wk	50 dead chickens or meconium from 250 chickens taken from the hatchery (ac) 2 pairs of sock samples (d)	Bacteriologic Bacteriologic
Hatchery	After each hatching	Wet dust	Bacteriologic
Rearing egg production	Day-old chickens 3 wks 12 weeks	10 samples of crate material and 20 dead chickens 5x2 sock samples in floor production units or 300 fecal samples 5x2 sock samples in floor production units or 300 fecal samples, and 60 blood samplesb	Bacteriologic Bacteriologic Bacteriologic, serologic
Egg production	Every 9th wk for eggs sold to authorized egg-packing centers	2 pairs of sock samples in floor production units or fecal samples and egg samples	Bacteriologic, serologic
	Every 6 mo for eggs sold at barnyard sale	2 pairs of sock samples or fecal samples and egg samples	Bacteriologic, serologic

(a) Requirements of the European Union Zoonosis Directive (92/117/EEC).
(b) Samples taken by the district veterinary officer.
(c) Samples taken by the district veterinary officer every 8 weeks.
(d) Samples taken by the district veterinary officer every 3 months.

The introduction of the British Egg Industry Council Lion Quality Code of Practice (1998) has had a dramatic impact on the spread of disease in the UK. In order to mark your eggs with the Lion seal, the code outlines the standards for bacteriological testing as well as mandating vaccinations against SE. Currently, more than 80% of the eggs produced in the UK carry the Lion seal (britegg.co.uk, 2011). The Lion code sets guidelines for farms to follow regarding hygiene practices, time and temperature controls on-farm, egg packages, feed and cage usage (see Addendum A). All the guidelines must be followed by the farmers prior to registration and each egg produced can then carry the Lion seal (britegg.co.uk, 2011).

In the United States, identifying risks to human health can be tracked through the use of Hazard Analysis & Critical Control Points (HACCP) management systems (FDA, 1997). HACCP is defined by the FDA as: a systematic approach to the identification, evaluation, and control of food safety hazards. This approach is based on these principles:

Table 3: HACCP Final Rule 1998 (US FSIS, 1998)

Principle 1:	Conduct a hazard analysis
Principle 2:	Determine the critical control points (CCPs)
Principle 3:	Establish critical limits
Principle 4:	Establish monitoring procedures
Principle 5:	Establish corrective actions
Principle 6:	Establish verification procedures
Principle 7:	Establish record-keeping and documentation procedures

Currently, the FDA does not require that egg producers follow a HACCP plan.

Housing type used in production flocks can also influence the spread of SE (Azakura, et al., 2001; Castellan, et al., 2004; Nordentoft, et al., 2011). Whether or not the difference is due to the air circulation of the caging used, water availability and source, or manure removal technique, still requires further study. Nordentoft, et al., (2011) could not determine that caging systems had any impact on the intestinal micro biota of the laying hens. However, chicks that were experimentally infected and housed at high densities in unsanitary conditions had an increase of SE (Azakura, et al., 2001). Overall, there is more evidence to support increased sanitation and air flow as minimizing SE factors in rearing systems rather than choice of cage type.

Vaccines

Vaccines are available to control the spread of *Salmonella spp* through a poultry flock and can be a useful tool in reducing public health risks. The use of vaccinations and their usefulness depends upon several factors, including the prevalence of serovars in a flock, general health of the flock, and type of production of the flock. Farming practices and hygiene are additional factors that can influence efficacy. Vaccines may also be used in some organic (nonconventional) farming systems (USDA, 2000).

Inoculation of hens to aid in prevention of SE outbreaks has both positive and negative aspects. Programs of vaccination are utilized to help decrease hen's susceptibility to naturally occurring *Salmonella spp*. Inoculation is an attempt to minimize SE prevalence within the hen as well as the hen's environment (Murray, 2000; Holt, 2000). Due to the large number of subtypes of the *Salmonella* bacteria, one vaccine cannot be effective against each subtype. Vaccination programs need to also incorporate other measures to aid in decreasing the presence of SE. Several of these measures are mandated by the new federal regulations effective in July, 2010. Currently, live SE vaccines are not allowed in the United States (Holt, et al., 2010). *Salmonella spp* vaccines are currently authorized for use in the United Kingdom, both live and inactivated are available. Different member states of the UK have different controls over the use of these vaccines (FSA, 2013).

Both live and inactivated *Salmonella spp* vaccines are available in the U.K. Vaccines can decrease the public health risks by reducing the colonization of reproductive tissues as well as reducing fecal shedding. Vaccines are used as tools to control the most common serovars of human infection (SE and ST). These vaccines, however, are not effective in controlling the multitude of other serovars that may exist on a poultry farm. Breeding hens and laying hens will require different types of treatment programs to control *Salmonella spp*. In order to reduce shedding by pullets, live and/or inactivated vaccines can be safely used. In order to reduce shedding and egg contamination by layers, only inactivated vaccines can be used due to the risk of spreading the vaccine strain to the eggs. The use of inactivated vaccine in laying hens will not eradicate the serovars SE and ST because it does not eliminate shedding. The effort to control the spread of the bacteria cannot be effectively achieved through vaccination alone.

Vaccines can decrease public health risks caused by *Salmonella spp* in poultry products by reducing the colonization of reproductive tissues as well as reducing fecal shedding. A number of different experimental strategies have been taken to study the efficacy of the *Salmonella* vaccines available, it is difficult to compare the commercial vaccine preparations for their level of protection, the duration of protection, or safety for humans and the environment. There is experimental and some limited field evidence that a reduced level of fecal excretion and systemic invasion of *Salmonella spp* organisms in vaccinated birds will result in a reduced contamination of table eggs and the environment. However, further information is still needed on the level and on the duration of protection after vaccination under field conditions. The control program in place in the UK has had the effect of decreasing human cases of salmonellosis by 50% between 1997 and 2001 (Cogen and Humphrey, 2003).

Vaccines can have an unintended side effect of creating a flock susceptible to new serotypes to fill the niche left by SE. Another possible disadvantage of live vaccines would be the spread to the environment and/or to people. Although this has not happened with the current widespread use of vaccines, it is still a possible complication of live vaccination as a control method. Vaccination of a flock already infected may decrease the spread of the SE serotype within the flock, but will not protect the hens from other serotypes.

Post-Harvest Controls

Maintaining proper temperature controls after collection of eggs is a vital step in ensuring the safety of the egg. Keeping eggs in cold storage inhibits the growth of SE within the egg (Gast and Holt, 2000). Additionally, safe handling during transportation also requires adequate temperature control measures.

The pasteurization process for eggs is intended to destroy microorganisms that have the potential to cause disease; microorganisms such as SE. Large quantities of eggs removed from their shells, sold to commercial establishments, are pasteurized in raw form and sold as a liquid. Pasteurizing eggs in the shell require a special handling process. Egg whites will begin to solidify at 60º C (140º F). In order to pasteurize an egg using heat without denaturing the egg, the egg should be heated up slowly to 57° C (134º F) and maintained at that temperature for 1 hour. Following this protocol will help to provide a safer final product for use in recipes that may not be fully cooked, such as a hollandaise sauce, eggnog or mayonnaise. After pasteurization, the eggs must be kept refrigerated to maintain the safety of the egg. If the pasteurized product is not kept at proper temperatures during transportation and/or preparation, microorganisms may still contaminate the egg (CDC, 2011; USDA, 2011).

Inadequate refrigeration, improper handling and insufficient cooking are all factors that also contribute to human disease outbreaks. Eggs are eaten undercooked or raw in many instances. Food items prepared in restaurants increase the risk of infected eggs contaminating healthy eggs through preparation of large batches of eggs. Combining many eggs in a batter or preparation for scrambled eggs can increase the possibility of infection (Braden, 2006; Patrick, et al., 2004). Eggs recipes properly prepared in individual servings and promptly eaten are rarely a problem. Eggs that have been handled and cooked properly should not cause human illness. Unfortunately, the habits of people to continue eating food in an unsafe manner cause the continued threat of salmonellosis to public health throughout the world.

Conclusions

The 2010 Iowa outbreak should serve as a reminder that constant surveillance is necessary to ensure the safest product reaches consumers. Current control measures in the U.S. have proven insufficient. The dependence on tracking the infection post-illness misses a key step in public health: prevention of human infection. The USDA and FSIS do not have the ability to ensure another outbreak will never happen again because it is fundamentally impossible to produce a 100% safe egg. The focus of controlling SE should be in risk reduction and prevention.

In order to maximize the safety of all eggs, a comprehensive EQAP with certification should be established in the U.S. This program would utilize the guidelines for a HACCP system. Recognizing the Critical Control Points (CCP) from farm to fork for an egg will aid in minimizing risk factors. An effective EQAP would also include the use of the best management practices (BMPs) for everyone involved in the production of an egg. Establishment of pre-harvest BMPs in order to comply with hygiene and safety protocols is only one step in the process. Once CCPs have been identified, along with the actions and procedures that follow, this information needs to be shared. A separate program for training and maintaining certification will need to be established.

Everyone involved has a stake in the safety of eggs, from production to processing to table. These procedures need to be taught to future handlers as well. Methods for disseminating training and information need to be addressed when the program is initiated. Actions to be taken after a failure to follow protocols must also be established. Although following all the safety program steps cannot guarantee SE free eggs, it can provide consumers with reasonable assurance that care was taken to ensure the safety of the eggs.

Eggs are a major source of the *Salmonella spp* outbreaks of salmonellosis in humans. Reducing the infection of chickens and eggs in production is a logical step to reduce human infections. Controlling the spread of SE through a flock is the first step in ensuring public health and safety. It makes sense to try eliminating the public health risk by creating a program that controls the spread of SE in poultry farms. Incorporating all the tools available to maintain a healthy flock will lead to a healthy egg product. Pre-harvest control measures such as monitoring, hygiene practices, cage usage, and vaccines can all be used in efforts to increase public safety. The combination of mandatory EQAPs in all states along with certification for egg producers would be beneficial; however, the cost of such a program is unknown. A majority of the post-harvest control methods depend on the consumer to take responsibility for proper storage and preparation; however, there are many steps the producer can take to ensure public health.

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Appendix A

SUMMARY OF LION QUALITY CODE OF PRACTICE

The Code of Practice for Lion Quality eggs covers breeding flocks and hatcheries; pullet rearing; laying birds, including both hygiene and animal welfare requirements; on-farm handling of eggs; distribution of eggs from farm; feed; hen disposal; packing centre procedures; advice to retailers, consumers and caterers; environmental policy and enforcement.

The Lion Code of Practice is accredited to the EN 45011 international auditing standard.

Registration and traceability
To guarantee traceability, all breeding farms, hatcheries, rearing and laying farms, feed mills and packing centres involved in the production of Lion Quality eggs must be approved. All Lion Quality hen flocks must be accompanied by a passport certificate and all Lion Quality egg movement has to be fully traceable.
The British Egg Industry Council (BEIC) maintains a 'live' database of all BEIC subscribers. It also maintains a register of inter-traded Lion eggs.

All British Lion eggs are marked on farm with the producer establishment number, which shows the system of production, country of origin and the farm where the eggs were laid.

A website – www.lioneggfarms.co.uk – also allows consumers to trace eggs back to the farm from the code on their eggs.

Breeding flock controls
Hygiene controls for breeding flocks and hatcheries include hygiene swabbing of hen houses, regular microbiological monitoring of parent flocks and hatcheries, with slaughter of any flocks positive for salmonella enteritidis or typhimurium, and heat/acid treatment of feed.

Pullet farms/vaccination programme
All birds destined for Lion Quality egg-producing flocks are vaccinated against *Salmonella enteritidis* using an approved vaccine.

A full hygiene monitoring programme including hygiene swabbing must be completed by pullet rearers before birds are taken onto the farm. Rearing flocks are tested for salmonella and all equipment and vehicles used for transporting pullets to the laying unit must be disinfected. Records of bird movement and salmonella testing must be kept on the passport. There are also controls on wild birds and rodents.

Laying birds

The Code sets out detailed hygiene requirements for laying hens, including disinfection of farms between flocks; prevention of cross-infection; salmonella testing; control of wild birds and rodents and detailed record keeping.

Time and temperature controls on-farm

Lion Quality eggs are subject to tighter controls on time and temperature than required by law. Lion Quality eggs must be stored below 20°C in hygienic conditions on the farm.   Production records and cleaning schedules must be maintained on site. All Lion Quality eggs must be transported to the packing centre at least twice a week and must be kept at a constant temperature below 20°C.

Controls on egg packs

All eggs must be accompanied by written documentation for proof of identity including age of lay, type of production and farm of origin. If fibre keyes trays are used, free range, barn, organic and caged eggs must each be packed on different colour fibre trays.

Strict controls on feed

Feed for Lion Quality hens must be produced to the Agricultural Industries Confederation's UFAS (Universal Feed Assurance Scheme) Code of Practice. Feed samples and records of deliveries and usage must be kept and measures taken to prevent on-farm contamination of feed.   In addition to the UK legislative ban on ingredients derived from mammalian sources, avian ingredients are also prohibited from feed for Lion flocks. A number of other ingredients are also banned, including the colourant canthaxanthin, and any raw materials likely to produce taint.

Packing centre hygiene

Written HACCP controls must be in place at Lion Quality egg packing centres and traceability of product and records must be kept at all times. Packing centres must ensure all eggs supplied are from approved producers. Written cleaning schedules and rodent control procedures must be in place. Effective crack and blood detection must be used in the grading of Lion Quality eggs. Full quality records must be held on site for a minimum of two years.

'Best before' date and Lion Quality mark on shell

Lion Quality eggs must carry a 'best before' date and the Lion mark on the shell and on the pack. All Lion eggs have a best-before date of no more than 27 days from lay, making them fresher than required by law. Most Lion Quality eggs are packed within 48 hours of lay.

Advice to retailers, consumers and caterers

Retail customers must be advised that Lion Quality eggs should be stored at a constant temperature below 20°C, away from heat sources and sunlight. They should be sold in strict rotation. On catering premises and in the home, eggs should be stored, preferably in their packs, in a refrigerator.

Environment policy

All Lion Quality egg subscribers must develop their own environmental policy especially in regard to manure disposal, disposal of dead birds, wastage and environmental impact on the community.

Animal welfare

The Code includes a number of animal welfare requirements which exceed those required by law. These include the banning of induced moulting, additional staff training procedures and procedures for the handling of end-of-lay hens in accordance with the Joint Industry Welfare Guide to the Handling of End of Lay Hens and Breeders. The Code mirrors the RSPCA's Freedom Food standards for free range and barn egg production.

All Lion cage eggs come from hens kept in the new larger, enriched 'colony' cages.

Ban of ‘farm’ descriptions of cage-produced eggs

Printing on Lion Quality egg boxes containing cage-produced eggs must not describe the eggs as ‘farm eggs’ or depict hens roaming free or farmyard/ countryside scenes.

Independent auditing

All Lion Quality registered premises are inspected and approved by an independent monitoring agency. BEIC maintains up-to-date lists of Lion Quality packing centres, laying farms, rearing farms, hatcheries, breeding farms and feed mills. On supply of details of these premises to the BEIC, certificates of registration are issued to the premises involved. Each site must carry out a self audit every six months and every other audit must be accompanied by a BEIC subscriber. There are also two audits every 18 months, one of which is unannounced, of each Lion Quality egg packing centre by the independent monitoring agency. Every Lion farm is also independently audited, including random unannounced audits. Any critical non-conformance results in immediate suspension from the Lion scheme, pending appropriate remedial action and there are also financial penalties for critical non-conformances at packing centres; lesser non-conformances have to be corrected within 28 days.

- ends -

For further information please contact The British Egg Information Service on
020 7052 8899

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