Egg Processing - Ideas for the Future

by

Glenn W. Froning

University of Nebraska
Lincoln NE 68583-0919

Introduction

In the past, most eggs were believed to be essentially sterile at the time of laying. As far as spoilage organisms this is likely true, but now food borne illnesses have been associated with Salmonella enteritidis (SE). Thus, it is known presently that some eggs may be infected with SE either by the transovarian or oviducal route (Duguish and North, 1991). Therefore, we know now that Salmonella transfer through the shell after laying is not the only means of contamination. Nevertheless, transfer of Salmonella through the shell after laying becomes an important consideration in reducing Salmonella contamination in shell eggs. The industry must endeavor to keep any microbial loads down by handling and cooling methods to better eliminate any possible pathogens in shell eggs.

Egg Characteristics

The egg does have several defense mechanisms that help reduce microbial loads in the shell egg (Board and Tranter, 1995) (Table 1). The shell cuticle is washed off since virtually all eggs are washed in the United States. Even if the cuticle were in place on the egg shell it is believed to be a poor barrier to bacteria. The egg shell has approximately 9,000 pores which readily allow penetration of bacteria to the shell membranes. The shell membranes do offer some resistance to bacterial penetration. Nevertheless, bacteria can eventually penetrate through the shell membrane. Tune et al. (1979) reported using scanning election microscopy that Pseudomonas fluorescens could

Presented at the University of California Egg Processing Workshop
Riverside and Modesto on June 2-3, 1998.

penetrate the shell by enzymic breakdown of the cuticle and shell membranes. In fact, they indicated that this type of infection through the shell is the most common means of contamination. Therefore, this aspect emphasizes the importance of handling and cooling after the egg is laid.

The egg albumen has several potential bacterial inhibitors (Table 2). Lysozyme and ovotransferrin (conalbumin) have been reported to have the most inhibition capabilities. Conalbumin provides optimum inhibition capabilities at alkaline pH (pH 9.5) conditions.

The egg yolk is an excellent media for bacterial growth. Therefore, once microorganisms penetrate the vitelline membrane and reach the yolk they will readily grow.

Handling Factors

After the egg is laid, several handling factors may affect bacterial contamination and quality of the shell egg (Snyder, 196 1). These factors are very important to achieve low bacterial counts and minimal Salmonella contamination in shell eggs (Table 3).

Most eggs today are gathered or transported from the laying house on mechanical belts at least three or four times a day. The longer eggs are held in the laying house the greater the opportunity for bacterial contamination on the shell. Bacterial contamination may arise from fecal material and the general environment of the laying house.

After gathering, eggs are stored and cooled at the farm until being sent to a central processor or egg breaker about three or more a week. Eggs at the farm level are generally cooled to, 13 ° C (55 °F) to 16 °C (60 “F). These temperatures have been utilized primarily to minimize sweating in eggs during transportation. Optimum relative humidity is generally around 75-80%. Today, virtually all eggs are washed at a central processing plant.

Washing of all eggs is generally accomplished at the central processing plant or egg breaker. Eggs need to be washed at temperatures at least 11° C (20”) higher than the egg temperature. An approved detergent sanitizer must be used generally at a water temperature of at least 43 ° C (110 °F). The most common sanitizer is one of several chlorine based compounds.

Lucore, et al. (1997) proposed washing eggs at a lower temperature to avoid increasing the egg temperature (Table 4). They postulated that earlier washing recommendations using emmersion techniques do not apply today. We now use spray washers. These scientists found that washed eggs at 15.5°C (60°F) as compared to 32.2°C (90°F) or 48.9°C (120°F) did not increase internal shell bacterial counts.

Before packing of eggs, they are required in some states to be cooled to 7.2 °C (45 °F) to limit growth of SE. The USDA also developed a similar regulation in 1993.

Several recent studies related to cooling of eggs have provided further insight into the importance of cooling of eggs. Gast and Beard (1992) orally inoculated laying hens with a phage type 13a strain of SE. (Table 5) One group of eggs from the inoculated hens was sampled on the day of collection, one group was held for 7 days at 7.2°C and a third group was held for 7 days at 25°C. Only 3% of the freshly laid eggs and 4% of the eggs held for 7 days at 7.2°C were contaminated with SE. However, 16% of the eggs from the 25 °C were contaminated with SE. Contaminated eggs from all three groups contained relatively small numbers of SE (less than 1 O/ml and rarely exceeding 100/ml). Nevertheless, longer storage periods likely would have produced increased numbers. Saeed and Koons (1993) artificially inoculated eggs with SE also observed substantial growth in eggs stored at room temperature for 2-3 days. However, minimal or no growth occurred in refrigerated eggs at 4 °C.

These authors further found that refrigerated storage (4 °C) was necessary to reduce growth and rate of penetration into the egg. Some researchers are now investigating new cryogenic approaches to rapid chilling of shell eggs.

These studies emphasize the need to adequately cool eggs to minimize growth of SE. The first goal is to reduce any possible contamination through the bird and the shell. Through proper washing, handling and cooling any potential contamination can be greatly reduced in the shell egg. Cooling procedures used today likely need re-evaluation (Tables 6 and 7). Eggs are sometimes stacked on filler-flats or packed into cases prior to proper cooling. New stacking procedures or designs are needed to allow adequate air flow around the eggs so that cooling is quicker. With the lower temperature of 7.2 °C (45 °F) there is also need to again look at the sweating problem. When eggs move through market channels, the 7.2 °C storage temperature will present a wider differential between storage temperatures and outside temperature. Thus, eggs at the loading dock may have the potential of sweating particularly at excessively outside warm temperatures.

Cooling of eggs is important to help prevent contamination of SE (Kenner and Moats, 198 1) Chen et al. (1996) found that refrigerated storage (4 °C) reduced growth and rate of penetration into the egg. Improved rapid cryogenic cooling methods are now being investigated. Their results indicated that eggs could be rapidly cooled with cryogenic gases, while improving Haugh units and reducing internal and external bacterial counts (Table 8). Some increase in cracks were noted due to cryogenic cooling (Table 9).

Another aspect being pursued recently by the egg product's industry is re-evaluation of pasteurization liquid egg products. Several issues have led to this need (Table 10). Although there have been no known salmonella outbreaks from pasteurized egg products, there is a need to update present guidelines which were developed 30 some years ago.

There have been many advancements in liquid egg pasteurization through the years (Table 11). Recently there have also been other methods of pasteurization emphasized including electroheating, pulsed electric fields, hydrostatic pressure and irradiation. Although irradiation is old technology, there has been renewed interest recently (Table 12). Another area recently showing promise is egg shell pasteurization. Some firms are now test marketing pasteurized shell eggs.

Summary

As we look ahead to changing our cooling, washing and pasteurization methods, the industry has some real challenges. Further research is needed to fully understand and implement these egg processing changes.

REFERENCES

Barrow, P.A. and M.A. Lovell, 1991. Experimental infection of egg-laying hens with ***Salmonella-enteritidis*** phage type 4. Avian Pathol. 20: 335-348.

Board, R.G. and H.S. Tranter, 1995. In Egg Science and Technology. Editors W. J. Stadelman and O.J. Cotterill. Haworth Press, Inc. New York.

Curtis, P.A., Anderson, K.E. and Jones, F.T., 1995. Cryogenic gas for rapid cooling of commercially processed shell eggs before packaging. J. of Food Prot. 58:389-394.

Chen, J., R.C. Clarke and M. W. Griffiths, 1996. Use of luminescent strains of ***Salmonella enteriditidis*** to monitor contamination and survival in eggs. J. of Food Prot. 59: 915-921.

Duguid, J.P. and North, R.A.E., 1991. Eggs and ***Salmonella*** food poisoning; an evaluation. J. of Med. Micro. 34: 65-72.

Egg Pasteurization Manual, 1969. Western Utilization Research and Development Division, Agricultural Research Division. Albany, California.

Gast, R.K. And C. W. Beard, 1992. Detection and enumeration of ***Salmonella enteritidis*** in fresh and stored eggs laid by experimentally infected hens. J. of Food Prot. 55: 152-l 56.

Kinner, J.A. And W.A. Moats, 198 1. Effect of temperature, pH and detergent on survival of bacteria associated with shell eggs. Poul. Sci. 60:761-767.

Lucore, L.A., Jones, F.T., Anderson, K.A. and Curtis, P.A., 1997. Internal and external bacterial counts from shells of eggs washed in a commercial-type processor at various wash-water temperatures. J. of Food Prot. 60: 1324- 1328.

Saeed, A. M. And C. W. Koons, 1993. Growth and heat resistance of ***Salmonella enteritidis*** in refrigerated and abused eggs. J. of Food Prot. 56:927-93 1.

Snyder, E.S., 1961. Eggs. The production, identification and retention of quality in eggs. Publ. No. 446 Ont Agric. Coll. Guelph, Ontario, Canada.

Stadelman, W.J., and Rhorer, A.R., 1987. Egg quality: which is best - in-line or off-line production? Egg Ind. 93:8-10.

Tung, M.A., M.E. Garland and P.K. Gill, 1991. A scanning election microscope study of bacterial invasion in the hens egg shell. J. Inst. Can. Sci. Techol. Aliment. 12:16-22.

TABLE 1

PHYSICAL BARRIERS TO BACTERIA IN THE EGG

Cuticle - poor barrier

Egg shell - poor barrier

Egg shell membranes - good barrier

TABLE 2

CHEMICAL BARRIERS TO BACTERIA IN THE EGG

ALBUMEN (BOARD AND TRANTER, 1995)

Lysozyme	Lyses of bacteria
Ovotransferrin	Chelates metal ions
Avidin	Binds biotin
Ovoflavoprotein	Binds riboflavin
Ovomucoid	Binds trypsin
Ficin	papain inhibitor

TABLE 3

HANDLING FACTORS AFFECTING-SHELL EGG

BACTERIAL CONTAMINATION

Frequent gathering

Proper cooling and humidity conditions

Proper washing (central processing plant)

Careful handling to avoid breakage

TABLE 4

Washing Methods (Lucore et al., 1997)

- Washing at low temperatures 15.5 °C did not increase bacterial counts in eggs as compared to conventional washing techniques.
- Should washing temperatures be changed?
- Effect on pathogens?

TABLE 5

RECOVERY OF SE FROM THE CONTENTS OF FRESHLY LAID AND STORED EGGS PRODUCED FROM EXPERIMENTALLY INFECTED HENS (GAST AND BEARD, 1992)

	% SE Positive
Freshly laid eggs	3.0
Eggs stored 7 days at 7.2°C	3.7
Eggs stored 7 days at 25°C	15.9

TABLE 6

PROBLEMS

Stacking filler flats and packing warm

Sweating

TABLE 7

Conventional Cooling

- 142 hr to cool eggs to ambient temperatures on pallets (Anderson et al., 1992)
- Days to cool if packed warm in carton (Stadelman and Rhorer, 1987)

TABLE 8

Cryogenic Cooling

(Curtis et al., 1995)

- Improved Haugh units
- Reduced bacterial counts
- Some increase in cracks

TABLE 9

Cryogenic cooling affects internal

temperature and cracks (Curtis et al., 1995)

Cooling Time min	Internal Temperature °C	No cracked %
3	15.2	2.1
6	11.1	5.7
9	7.8	12.9
12	3.2	24.8

TABLE 10

Need for Re-evaluation

Better methodology

Eggs marketed more rapidly

Increased concern of *S. enteritidus*

New egg blends with different formulations

Thermal resistance of ***Salmonella*** in Salted Yolk

TABLE 11

<u>Equipment</u>

HTST system (heating, cooling, regeneration)

Flow diversion value

Clean in place

TABLE 12

New Technologies

Electroheating - (Reznick and Knipper, 1994)

High-intensity pulsed electric fields (Qin et al., 1995)

High hydrostatic pressure (Mertens and Knorr, 1992)

Irradiation