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Designing a HACCP Plan for Shell Egg Processing Plants

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Egg temperature (initial and throughout processing and storage), and wash water pH and temperature play key roles in reducing microbial growth in shell eggs, and should be key in developing a HACCP plan for shell egg processing plants. Many processors are initiating their own Hazard Analysis Critical Control Points plans to get a jump on anticipated future regulatory needs. We have compiled data from published research related to the shell egg processing environment which could be helpful when developing a HACCP plan. Board and Tranter (1995) noted that shell eggs can acquire bacteria from every surface they contact.

Incoming eggs:

Egg temperature at processing is very important. USDA regulations require that wash water temperature be at 90 F or higher, or at least 20 F warmer than the highest egg temperature (which ever is greater). These temperatures must be maintained throughout the cleaning cycle. Temperature of incoming eggs will vary from season to season and from operation to operation. In off-line processing plants (where eggs are brought in from off-premises) initial internal egg temperatures of 62 to 68 F (16.7 to 20 C) are likely. Although pre-processing coolers are held generally between 50 to 60 F, egg temperatures decline only slightly. Egg temperatures at processing reflect initial internal temperatures generally, because eggs are brought into the processing plants (where the processing plant is adjacent to production facilities) internal egg temperatures range generally from 88 to 96 F (31.1 to 35.6 C) when they reach the processing area.

Regulations require also, that wash water be changed every four hours or more if needed, to maintain sanitary conditions. When the difference between wash water temperature is > 40 F, thermal checks and cracks increase, allowing surface microbes greater access to the interior of the egg.

Contact between wash water and eggs during processing causes internal egg temperature to increase. Although blow drying following washing causes a slight decrease, internal egg temperature rises generally throughout the process, and can continue to rise for up to six hours after eggs are placed in a cooler.

According to USDA regulations eggs can not be immersed at any time, but may be pre-wet prior to washing if sprayed with a continuous flow of water-of similar temperature to that of the wash water-which drains away.

Egg washer:

Cleaning eggs during washing is related to: wash water temperature, water quality characteristics (i.e. hardness, pH), detergent type and concentration, and defoamer. Replacement water in washer tanks should be added continuously to maintain a constant overflow rate, according to USDA regulations. Chlorine or quaternary ammonium sanitizing compounds may be used as part of replacement water provided they are compatible with the detergent. Only potable water may be used to wash eggs and USDA requires a certificate to this effect (USDA, 1991). Rate and extent of bacterial growth during storage is favored by washing eggs in water with less than two ppm iron, so it is important to monitor the iron content of the wash water. USDA suggests that water with an iron content in excess of two ppm should not be used unless deionized (Baker and Bruce, 1994). Iron contamination may influence microbial growth when shell membranes are penetrated. As bacteria grow on membranes in an iron-rich environment, they can produce metabolic products which allow microorganisms to penetrate and diffuse into the albumen, providing a more favorable medium for microorganism growth, able to satisfy their iron requirements. Most processors use wash water much hotter than the minimum 90 F. A survey by Anderson *et. al*. (1992) found North Carolina processors' use wash water temperatures that range from 115 to 120 F. In 1955, Hillerman reported that wash water maintained at 115 F would increase internal egg temperature by 0.4 F/second.

Product chosen as detergents and the detergent dispenser must be listed as approved for use on eggs in the current List of Propriety Substances and Nonfood Compounds (USDA), FSIS, Miscellaneous Publication Number 1419. The best approach for reducing microbial populations in wash water tanks, and therefore on eggs, occurs when detergents are added in amounts sufficient to maintain a pH of 11.

Alkaline cleaning formulations produce an initial pH in the wash water near 11, and pH during operation continues in the 10-11 range usually, unfavorable for growth of most bacteria (Moats, 1978). However Jones et al (1995) isolated *S.heidelberg* from the shell of a commercial egg processed in water with a pH of 10.2. Two Canadian researchers, Holley and Proulx (1986), found Salmonella species were able to survive at 38 and 42 C (100.4 and 107.6 F) when washwater pH was less than or equal to 9.5. Alkaline pH has been reported to increase the sensitivity or Salmonella to heat (Anellis *et al*., 1954; Cotterill, 1968). Kinner and Moats (1981) found that at pH 10 and 11 bacterial counts decreased regardless of water temperature. They reported that bacterial counts decreased at 50 and 55 C (122 and 131 F) regardless of pH, also. Laird *et. al.* (1991) indicated, however, that current processing practices are not sufficient to prevent potential contamination of washed eggs with *Listeria monocytogenes*. Their study showed that Listeria is isolated readily from egg processing environments, including wash water.

Because a number of research studies have shown that a pH of 10 to 11, or above is necessary to control bacteria, pH is a relatively inexpensive variable to monitor, and others significant protection against such bacteria as *Salmonella enteritidis*.

Many shell egg processors have no idea what the pH of their wash water is. Often, those who monitor measure pH only at the start of a shift. PH may be 10 or 11 at the beginning of the shift, but recycling wash water, overflow losses and added replacement water all contribute to reduce pH levels. Detergents elevate the pH of egg washers and are dispensed, for the most part, in concentrations necessary to clean the egg shell. Minimal thought to maintaining a constant pH occurs. When dual tank systems are used, pH in each tank can be different, depending on how the wash systems are connected.

The Food Production and Inspection (FPI) Branch of Agriculture Canada monitors egg grading stations routinely in Canada, to ensure that egg washing guidelines are followed. Guidelines include: maintenance of wash water at a temperature of 43±3 C (109±6 F); maintenance of wash water at pH 10; maintenance and routine cleaning of washers and their parts (e.g., brushes and rollers); and complete change of wash water and cleaning of holding tanks every two to four hours (FPI, 1983). These guidelines were developed to eliminate pathogens that may be present in the wash water and to minimize microbial contamination of the washed eggs. At present, bacterial numbers in egg wash water are monitored to ensure that adequate sanitation is achieved. Total viable counts >105 cfu/ml are considered unacceptable (Bartlett et al, 1993). The U.S. has only regulations governing wash water temperature and time between water changes in the tank, currently.

Defoamers play an important role in egg washing. When defoamers are not dispensed properly, foam in the wash tanks builds up and overflows eventually. When foam spills from the tanks, it can interfere with water level detection, and affect water temperature and pH.

Washing, drying, and candling unit operations are continuous generally.

Eggs detected as "dirties" at candling must not be soaked in water for cleaning, because soaking in water for as little as one to three minutes can facilitate microbial penetration through the egg's shell.

Rinse and dry:

After washing, the hot water rinse may contain chlorine, or quaternary sanitizers which are compatible with the washing compound. Iodine sanitizing rinse may not be used as part of the replacement water (USDA, 1991). Ambient air dries the eggs. At this point the surface temperature of the egg reaches approximately 95 F. Anderson *et al* (1992) found that the internal temperature of eggs continues to rise due to high shell surface temperatures and candling lights. Five minutes after the eggs were processed their temperature was 12 to 14 degrees above their initial temperature.

Shell eggs may be oiled then, provided operations are conducted in a manner to avoid contamination of the product. Processing oil that has been previously used and which has become contaminated, can be filtered and heat treated at 180 F for three minutes prior to reuse.

Storage:

Sizing and packaging in cartons or flats are placed in cases and cases are palletized. Efficient packaging procedures such as these ensure that high egg temperature, due to processing, will be maintained for several days. In fact, recent industry surveys by the authors suggest as much as a week is required to dissipate temperature increases from processing under these conditions. Yet, virtually everyone in the shell egg processing industry uses these or similar procedures. Federal law requires eggs be stored at 50 to 60 F. However, state laws can and do supersede this requirement. Many states have laws requiring eggs be stored at 45 F. Some states have laws requiring internal egg temperatures of 45 F.

Researchers have found that the growth rate of *S. enteritidis* in eggs responds directly to the temperature at which the eggs were stored, and that holding eggs at 40 to 45 F reduced the heat resistance of *Samonella enteritidis*. It has been suggested that refrigeration reduces the level of microbial multiplication in shell eggs, and lowers the temperature at which the organism is killed during cooking. This, in and of itself, may be adequate justification to store eggs at 40 to 45 F.

Humidity in the storage environment is important both in maintaining egg weight and preventing microbial growth. Storage relative humidities of 60% can cause weight loss and a corresponding increase in air cell size. However, storage in relative humidities of 80% can promote microbial growth.

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