Microbial update

eggs & egg products

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Eggs are produced by most higher animals as a part of their reproductive cycle. In terms of human food, it is eggs from a variety of birds that we consider to be a good food source. The apparent simplicity of the egg, a hard shell surrounding a liquid centre, hides its complex nature which makes it a versatile stable food in its own right, or food ingredient used widely within the industry.

Egg structure

The egg shell is constructed of forms of calcium carbonate (approximately 95%) together with a stabilising protein matrix. The protein helps in maintaining the structure of the shell and in reducing the effects of physical damage. The shell is key to maintaining the contents of the egg in good condition. It prevents entry of micro-organisms into the albumen and yolk, and it facilitates both gas and moisture transfer to the egg contents, keeping the egg 'fresh' for a considerable period. Comparing eggs with other raw animal derived foods, there are few others that remain fresh at ambient temperatures over considerable periods of time, without the help of considerable amounts of artificial preservatives. The egg is quite an amazing structure.

The inner liquid parts of the egg are made up of the 'white' (albumen) and the yolk. The white is made up of approximately 90% water into which is dissolved a variety of proteins (approximately 10% of the white). The white contains virtually no fat and only about 1% carbohydrate. After the shell, the white is the next level that the egg has against microbiological attack. It contains a range of potent antimicrobial agents including transferrins (these bind iron molecules that are a key requirement for microbial growth) and the enzyme lysozyme.

Lysozyme is a key antimicrobial enzyme that has evolved to break apart the hard outer wall of bacterial cells (made up of the polymer peptidoglycan). Lysozyme does not simply prevent microbial growth, it kills bacteria by breaking their outer defensive wall.

Egg yolk is composed of approximately 4% carbohydrate, 25% fat, and 10-15% protein. In a fertilised egg it would make up the main nutritional component for the developing embryo. Its distinctive colour comes from a number of carotenoid pigments that it contains. The yolk can contain large numbers of antibodies directed against bacteria and this forms part of the protection that eggs have against bacterial attack.

Egg microbiology

It has been stated (Board 2000) that eggs can become internally contaminated by micro-organisms in three ways.

- Trans ovarian infection – resulting from the yolk within an ovary follicle being infected, usually with organisms from the blood of the bird.
- Oviductal infection – where the egg white is infected during its movement along the oviduct. Organisms can be introduced into the oviduct via either the bird's vascular system, or by upward migration from the bird's cloaca, or via practices involved in artificial insemination.
- Trans-shell infection. The egg shell will be contaminated immediately on laying by contact with dust, faecal material and other environmental agents. It is known that the longer the egg is in direct contact with such contaminated material, the greater the chance of internal contamination occurring.

This is due to the large number of pores within the shell, which under the right conditions can transfer organisms across the shell into the egg interior. This transfer can be accelerated if eggs are placed in water.

Warm eggs placed in cold water result in an internal vacuum which can draw the water (and any contaminants on the outside of the shell) inside the egg, likewise any pressure changes can result in transfer into the egg.

Egg spoilage

The main cause of egg spoilage arises from the growth of Gram negative bacteria within the egg contents. There have been many studies on the types and causes of egg 'rots' and Board (2000) gives excellent descriptions of the various forms of egg spoilage.

If an egg becomes internally contaminated, there will be a lag before gross contamination of the egg contents becomes apparent. In eggs contaminated by the trans-shell route, this lag period can be between seven and greater than 20 days in length.

There are numerous reasons that have been suggested for this lag time, but it is likely to be due to changes in the egg structure during storage, making conditions more favourable to bacteria growth, perhaps together with some biochemical changes within the bacteria themselves helping overcome the egg's defensive mechanisms.

Pathogens and eggs

The predominant human pathogen that is associated with eggs is salmonella. This pathogen can be associated with eggs in two ways:

- It can be found on the egg shell, which can become contaminated from the bird's faecal material.
- It can be found within the egg contents, which become contaminated when the egg is being formed within the bird. This route is

Bacterium	Type of egg spoilage
Pseudomonas fluorescens	Pink rot
Ps putida	Fluorescent green rot
Ps aeruginosa	Fluorescent blue rot
Stenotrophomonas maltophilia	Green rot
Aeromonas liquifaciens or Proteus vulgaris	Black rot
Aerobacter spp. formally Cloaca spp.	Custard rot

known as trans-ovarian infection. Shell contamination can be controlled to some extent by ensuring that laying areas/ conditions are hygienic, and by carefully controlled washing of eggs (although great care has to be taken to avoid external contamination being drawn into the egg during the washing process). Trans ovarian infection can only be controlled by ensuring that birds are free from salmonella.

During the late 1980s and early 1990s, the annual incidence of reported human salmonellosis in the UK was at a record high of nearly 40,000 cases.

A large majority of these were due to S. enteritidis originating from poultry and eggs. At that time action was taken by poultry and egg producers, a vaccination programme against salmonella, for poultry breeding flocks (beginning in 1994) and egg layers (beginning in 1998), has resulted in a drastic reduction in contaminated poultry and eggs.

The results of this have been a huge success in reducing levels of contaminated eggs. A comparison of surveys of Salmonella contamination in raw shell eggs done for the UK Food Standards Agency in 1995 and 2003, show a three fold reduction in contamination over that period. The result was a dramatic decrease in cases of human salmonellosis from those seen in 1990 (approximately 40,000 cases) to that seen in 2012, of just over 8,000 (confirmed figures for 2013 are likely to be closer to 7,000 cases).

In the UK eggs produced from vaccinated flocks will bear the 'Lion Mark', and there has been concern, fuelled by a number of salmonella outbreaks, that eggs imported into the UK may have higher rates of contamination.

In 2006 a report on a UK FSA surveillance study on eggs imported into the UK, clearly indicated that imported eggs from some countries had a higher incidence of salmonella contamination than UK produced eggs.

It is obviously the responsibility of egg users to understand the risks involved in obtaining shell eggs from various sources and take appropriate management strategies to minimise the risk to the end consumer.

Egg products

The term egg products covers a wide range of food types that would be impossible to cover in any detail. In the commercial manufacture of any product containing egg, the main consideration will be what form the 'egg material' is in when used. Few industrial producers would use shell eggs within their products, most will user either pasteurised liquid egg or powdered egg.

Pasteurisation of eggs should provide an ideal way of extending shelf life by eliminating spoilage organisms and ensuring freedom from salmonella.

However, pasteurisation has to be very carefully controlled as higher temperatures will coagulate egg proteins and make an unusable product. Different countries will have different guidelines or standards on requirements for pasteurisation, and these should always be consulted when considering use of pasteurisation for eggs.

The required pasteurisation temperatures for whole liquid egg will lie between 60°C and 65°C for between 2.5 and 3.5 minutes. The higher temperatures will destroy the enzyme amylase, the absence of which can then be used as a marker for correct pasteurisation.

The addition of salt or sugar to the liquid egg before pasteurisation can increase the heat resistance of micro-organisms, and care must be taken to ensure that the pasteurisation process is sufficient for such products. Egg white is more sensitive to heat treatment than other egg products and generally is treated at lower temperatures. Its higher pH, however, means organisms such as salmonella are more sensitive to heat and the lower temperatures can give an acceptable kill.

The complexity of the pasteurisation issues can be appreciated when it is understood that the pH of the white can vary with the age of the egg; faster shipment of eggs from farm to processor can result in lower pH and less antimicrobial effect at a given temperature. Generally pasteurisation processes for liquid egg are designed to give an approximate 4-5 log reduction of salmonella. It is recommended that anyone considering pasteurising egg or using pasteurised egg, consults local national or international guidance on egg heat treatments and obtains an assurance that any process used has been correctly validated by a competent organisation that understands egg processing requirements.

Conclusions

Eggs are an excellent food, nutritious, easy to use, and with a excellent natural shelf life. We know that they are prone to spoilage by a range of micro-organisms, but good production, transportation and distribution together with chilled storage in the home can minimise this issue.

With respect to microbiological food safety, the main issues with eggs have always centred on salmonella. In the late 1980s the UK had a large and increasing problem with human salmonellosis which was largely due to contamination of poultry and eggs.

Intervention actions based on vaccination of laying flocks against salmonella has drastically reduced this problem, making British produced eggs far less likely to contain the pathogen than they were two decades ago. It is, of course, still recommended that eggs are properly cooked before consumption to lower the risk still further, but it is fair to say that eggs now form a very safe and nutritious food source.

A major concern has been that eggs imported into the UK may not have been produced under the same stringent conditions as UK eggs and may have a greater chance of containing salmonella.

A number of outbreaks of food poisoning have been linked to imported eggs, and surveillance would tend to back this up. It is up to users to ensure that they are aware of the risks from the shell eggs they use, and are taking appropriate actions to minimise risk to consumers.

Pasteurisation increases the shelf life of liquid egg and provides a pathogen free raw material for production of a range of egg products. Producers and users should always ensure that the pasteurisation processes used comply with local guidance or standards and gain expert help in validation of such processes. ■

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