Managing Perfection

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The egg's barriers to bacterial invasion

by Lotte van de Ven, Vencomatic

Contamination of hatching eggs can greatly depress hatchability and chick quality, and consequently affects profitability in the broiler industry.

It is important to realise that a sterile eggshell does not exist in practice: as the egg passes the highly contaminated cloaca of the hen, the shell will contain bacteria and every subsequent contact with the environment will further increase contamination.

However, the intact egg possesses several barriers that prevent bacterial penetration, including the cuticle, the shell, the shell membranes and the albumen. The first natural defence to protect the egg from bacterial invasion is the cuticle, a protein layer aligning the outside of the eggshell and sealing the pores of the egg.

The thickness of the cuticle is on average 2.3µm and varies with the age of the breeder flock, breed and management factors. At the site of the pores, the cuticle layer is much thicker, forming a plug 50µm deep which is probably crucial in the prevention of penetration of micro-organisms.

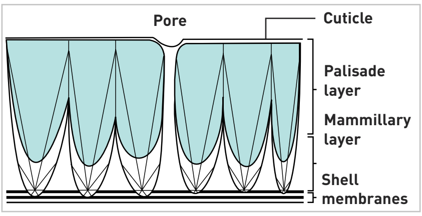

Fig. 1. Cross section of the eggshell.

The eggshell has between 7,000 and 17,000 pore openings, which do not all extend through the entire depth of the shell.

The diameter of the pores varies between 15-65 µm, which is far above bacterial dimensions and, as such, the shell has limited value as a barrier to bacterial penetration.

Although several researchers assumed a relation between eggshell thickness and/or the number of pores and the invasion of bacteria, this is not confirmed by recent studies.

Inside the eggshell proper, the inner and outer egg shell membranes are positioned in close contact.

The outer membrane aligns the eggshell and the inner membrane encloses the albumen. The inner membrane is the most effective filter to bacterial invasion.

The albumen provides a final barrier to micro-organisms. In the first place, the high viscosity of the albumen hampers movement of bacteria and secondly, there is a range of chemical substances with antibacterial function.

In addition, after oviposition the pH of the albumen rises from 7.6 to about 9.0 which is unfavourable for bacterial growth, which is optimum in a pH range of 6.5-7.5.

Although the egg has several barriers against bacteria, these are not completely adequate to prevent contamination.

Bacterial invasion especially occurs if a temperature gradient exists between the egg and its environment, and in the presence of moisture. As an egg is laid it enters an environment of about 10-20°C below the hen's body temperature and starts to cool.

During the cooling process the egg contents contract, causing negative pressure within the egg and thereby pulling bacteria from the egg surface into the egg. Additionally, after oviposition it takes several minutes for the cuticle to harden before becoming an effective barrier.

Hatching eggs at the point of lay are the most susceptible to bacterial penetration and providing a clean nesting environment must therefore be a key priority for breeder farm managers.

Clean eggs are the basis for good hatching results and high quality day old chickens. ■

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Consequences of bacterial invasion

by Winfried van de Laar, Vencomatic

The intact hatching egg has several barriers to prevent the invasion of bacteria. However, after the first half hour following ovoposition these barriers are not adequate to prevent bacterial penetration. In simple terms this means that even following egg disinfection there is no such thing as a sterile egg. Fortunately in most of the cases these bacteria are non-pathogenic residing harmlessly in and between the shell membranes.

The environmental conditions required for proper development of the chicken embryo closely match those needed for the growth of bacteria and moulds. The temperature and relative humidity in both hatchers and setters is optimal for bacterial growth both outside and inside the egg and especially when the conditions within the hatchers favours aerial growth of bacteria and moulds on the shell.

Bacteria inside the egg are using nutrients within the yolk which are meant for embryonic development. In some cases the resultant bacterial growth produces toxins detrimental or even fatal for the developing embryo.

Even if the embryo of a contaminated egg survives, the day old chick will be weak resulting in culling, early chick mortality or, at best, reduced performance in the growing house.

During the first stages of the incubation process the chance of cross contamination is limited. It is, or should be, standard hatchery practice to ensure hatching eggs have been disinfected and that there is no direct contact from egg to egg.

In the second half of the incubation the chances increase that contaminated eggs may explode due to the build up of gasses in the egg. This results in the egg contents, including pathogens, spreading throughout the incubator cabinet contaminating other eggs and is assisted by the fan-forced air within the incubator.

Eggs contaminated with bacteria can produce viable chicks but they then present a source for contamination for other chicks. It has been shown there is a potential for a large increase in presence of salmonella on eggshells during the last three days of incubation in the hatcher (Fig. 1).

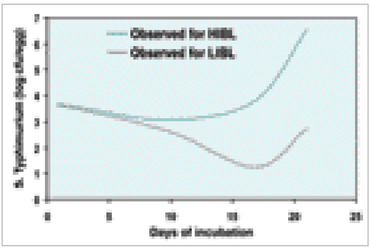

Fig. 1. Observed bacterial concentrations of Salmonella typhimurium in high initial bacterial load (dirty eggs: HIBL) and low initial bacterial load (clean eggs: LIBL) eggs at 1 day (holding), 10 days (candling), 17 days (incubation), and 21 days (chick processing) (Prahad et al, 2005).

Eggs carrying salmonella on the outside of the eggshell or in the shell membranes can lead to contamination of the chick at the moment of pipping of the eggshell.

The fluff generated during the hatch by infected chicks will further spread salmonella and other pathogens throughout the cabinet and to other areas of the hatchery.

Apparent clean hatching eggs carry thousands of bacteria both on and in the shell. Soiled and dirty eggs may have 10 to 100 times as many bacteria.

Those on the shell can be dealt with fairly easily by disinfecting the eggshell but bacteria that have penetrated the egg are very difficult to fight. The emphasis must be on prevention, which means collecting clean eggs on the farm from a healthy flock to produce good quality non-contaminated chicks. ■

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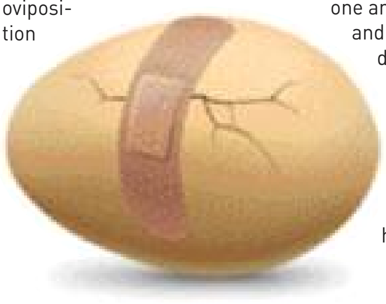
The impact of haircracks

by Koen Uitdehaag, Vencomatic

Hairline cracks severely affect the ability of the embryo to survive within the hatching egg since they reduce the ability of the eggshell to protect against microbial invasion and impair the respiratory process.

As the quality of the shell decreases with the age of the breeder, the eggs of older birds will be more susceptible to hairline cracks than those of younger birds.

Either visible or non-visible hairline cracks may occur all over the surface of the eggshell originating from a variety of external factors to which the hatching egg is exposed, from oviposition



until placement in the incubator.

The severity of the hairline crack negatively correlates with the probability of a successful hatch and therefore measures should be taken in order to prevent hairline cracks.

These measures should be related to bird management as well as to egg handling and egg transport.

After oviposition eggs should be removed from the nest as soon as possible, in order to prevent birds damaging them. In case of automatic collection eggs roll away onto the egg belt where they should be out of sight and picking range.

The angle and surface material of the nest floor area should allow eggs to roll gently onto the egg belt.

Birds should not be able to see the eggs stored on the egg belt nor to peck the eggs, as this will easily develop into routine-like-behaviour.

The egg belt should be wide enough to allow the maximum number to be held on the belt prior to collection. Frequent collection of the eggs (i.e. twice daily) will reduce the risk of damage, as fewer eggs will be in transit during each collection run.

In the transport of the eggs to the egg storage room which may involve passage through elevators, conveyors, egg packers or (un) loaders there is always a risk of mechanical damage causing hairline cracks.

Optimal adjustment of egg packing and transport devices to one another in terms of speed and position is essential in reducing the potential for hairline cracks.

Although beyond the farmer's control egg transport to the hatchery and handling within the hatchery, both in terms of placement in the setter and transfer to the hatchers, are critical moments for hairline cracks to occur after leaving the parent stock farm.

In the hatchery candling eggs at transfer from setter to hatcher involves selection of eggs containing undeveloped embryos of which hairline cracks may be a possible cause.

Changes in diet composition to improve egg shell strength of the breeder flock, particularly towards the end of the laying period, is important along with other measures aimed at smooth and gentle egg handling in each stage of egg transport.

Such measures will significantly reduce the risk of hairline cracks and consequently lead to improved hatchability and higher economic profit. ■

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Floor egg causes and consequences

by Wim Peters,
Vencomatic BV

The appearance of floor eggs is a potential major problem in broiler breeder production. Not only do these eggs have to be collected manually, requiring a lot more labour, but these eggs are more likely to be contaminated.

As contaminated eggs affect both hatchability and chick performance, broiler production will be negatively influenced through the appearance of floor eggs. Therefore it is very important to minimise the number of floor eggs.

The reason for hens to move to the laying nest for egg laying is the dark and secure hideout which the nests offers. This instinct to lay in a secluded spot is a natural one in order to be protected from potential predators.

Slight shade under the feeder line is a possible location for floor eggs.

The nest should be easy to reach and a comfortable nest surface should be provided. Slats in front of the laying nest will help the birds to find a suitable nest.

If there are insufficient nest boxes some hens will seek out less appropriate locations. It is not unusual, for example, for hens to find the slight shade under drinker or feeder lines as a favourable location for egg laying.

The light intensity in potential nest areas should be higher than the light intensity in the nest and in front of the nest.

In this way, the birds will prefer to go to the nest area for egg laying.

The importance of the airflow in a breeder house is often underestimated.

If the airflow is directed straight into the nest, some hens may look for an alternative place for egg laying to avoid the draught in the nest.

However, keep in mind that in hot climates air flow in the nest may be considered a positive factor in attracting birds to the nest.

The litter depth should not be too high as this may encourage floor eggs because hens will find it comfortable to nest in.

Litter depth should be kept to a maximum of approximately 2-3cm.

When hens start to show inappropriate nesting behaviour it can be difficult to correct and, therefore, it is important to react as early as possible to minimise the number of floor eggs.

The house should be visited several times throughout the day in order to collect the floor eggs. If needed, action can be taken to make the nest access easier and dark corners less attractive.

The management schedule is also important in floor egg prevention.

This schedule contains the times of light on/off, feeding times and nest opening and closing times.

It is important to know at what time of the day the majority of eggs are laid and adjust the management schedule accordingly.

During this period of lay running feeder lines should be avoided and the birds should not be disturbed as this will discourage some birds from using the nests. ■

Managing Perfection

Controlling embryo development

by Lotte van de Ven,
Vencomatic BV

Embryo development does not start in the incubators at the hatchery. At the moment a fertilised egg is laid, the embryo inside the egg has already gone through several stages of development. During about 24-26 hours between fertilisation and the moment of lay, the one-cell embryo has developed to an embryo that consists of 20,000-40,000 cells.

When taking a close look at this embryo, one can recognise the doughnut-like structure of the blastoderm, as it is called at this stage, with a white ring surrounding a more translucent area of cells. In this area, the area pellucida, the embryo is formed. Thus, although it is traditionally said that incubation of chicken eggs takes 21 days, one day of embryonic development has already passed before the egg is laid.

A hen in a roll-away nest.

There is quite some variation in the stage of embryonic development at the moment of lay, depending on the age and the breed of the parent flock, and the position of an egg within a sequence. It is known that the stage of embryonic development at lay is related to hatching results, and optimum stages were defined in microscopic studies, but the exact mechanisms are not fully understood.

What is generally accepted however, is that the climate conditions after lay influence the developmental stage and the quality of the embryo at the start of incubation. Embryonic development is almost completely arrested when temperatures drop below the so-called physiological zero of 21°C. At temperatures between 27° and 35°C, abnormal embryonic development may occur, and since this can result in embryonic mortality, these temperatures must be prevented both at the breeder farm and during transport and storage in the hatchery.

At the moment the hatching eggs are placed in the incubator, and the embryo temperature rises to 37.8°C, normal embryonic development is continued.

However, incubation may also occur at the breeder farm, when eggs remain in the nest under the breeder hen. In breeder farms where eggs are collected manually, a variation exists in the time the hen can sit on the eggs, resulting in a variation in developmental stage of the embryos within a batch of eggs.

Also, other hens visiting the nest and sitting on the egg, can cause temporal rises in egg temperature. Since more advanced embryos need less incubation time in the hatchery, these embryos will hatch earlier resulting in a larger spread in hatch. This will lead to early hatching chicks dehydrating as they are waiting inside the hatcher for chick removal, with subsequent losses in vitality and growth. In addition, when the breeder hen sits on the eggs for a longer period, the embryo may advance beyond the optimum developmental stage for incubation, leading to decreasing hatching results.

Therefore, in houses with manual egg collection, eggs should be collected as soon as possible after lay. In houses where eggs are collected automatically with roll-away nest boxes, the eggs roll away to an egg belt where temperature is uniform immediately after lay.

Consequently, the embryonic developmental stage will be homogenous in eggs of one breeder flock, forming the basis of a uniform hatch and optimum hatching results. ■

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Getting egg storage right

by Koen Uitdehaag, Vencomatic BV

Constant changes in market demand for day-old chicks and improvement of transport efficiency from broiler breeder farms to supply the hatchery lead to a situation in which hatching eggs have to be stored.

A farm or hatchery manager can apply several management tools to reduce the negative consequences of storage on hatchability and chick quality.

These tools should affect the complex interaction between the chicken embryo, the internal egg environment and the external environmental conditions during storage.

At the onset of storage, the number of viable cells within the chicken embryo is an important factor, especially through a prolonged storage period.

Although it has long been assumed that storage temperatures below the 'physiological zero' (between 20-27°C) would completely block embryonic development, recent studies have shown that in hatching eggs stored at temperatures below 20°C (some) embryonic development still continues.

However, this is not necessarily detrimental if the number of viable cells is not affected.

If prolonged storage times (for instance more than four days) are used, pre-storage incubation can be applied to increase the number of viable cells to better prepare the embryo for the storage period.

In younger flocks, studies have indicated that pre-heating eggs to 37.5°C for a six hour period improved hatchability of eggs stored for 14 days.

Storage time and conditions such as temperature and relative humidity (RH) and the age of the breeder flock, have effects on the quality of the internal egg environment (which can be assessed by, for instance, albumen height and pH and yolk pH).

Recommendations for storage temperature indicate 18-21°C for storage up to three days, 15-18°C for storage of 4-7 days and 10-12°C for storage over seven days.

Unlike storage temperature, RH does not strongly interfere with embryonic development, but low RH is known to increase the loss of moisture from the egg.

Therefore, it should be kept in mind that with increased storage time, the importance of higher RH levels increases.

During pre-incubation storage, regular turning of the eggs facilitates embryonic development by reducing the negative effects of storage on the shell membranes.

Furthermore, with storage up to seven days, hatching eggs should be placed with the point down, in order to maintain the central location of the yolk, and thus the embryo.

In conclusion, during storage complex physiological processes take place, which are not yet fully understood. Current knowledge does provide hatchery managers with tools related to pre-storage incubation, storage temperature and RH, turning and position of the eggs to minimise losses in final hatchability. ■

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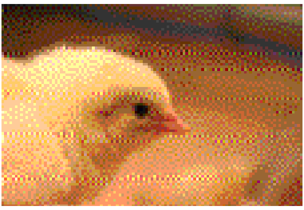
Post hatch consequences of dirty eggs

by Koen Uitdehaag, Vencomatic BV

The economic losses due to dirty hatching eggs not only result from possible embryo mortality at the hatchery, but also from decreased performance from day-old broiler chicks throughout the production period. Even if the embryo of a contaminated egg survives, the day old chick is expected to be weaker, resulting in culling, early chick mortality or at best reduced performance in the growing house.

Several studies have indicated



the possible transmission of bacterial populations from broiler breeder flocks to their broiler progeny.

Various transmission routes (i.e. through infected male semen) have been described which also include the contamination of hatching eggs after bacterial penetration of the dirty egg shell.

Therefore day-to-day management (i.e. opening times of the nests, feeding times etc) of breeder flocks already influences the performance of their broiler offspring.

The cleanness of the nest environment as well as the amount of floor eggs affect the presence of faeces and litter on hatching eggs, hereby also affecting the risk of contamination.

The infection (or dysbacteriosis) of the yolk sac may especially lead to increased mortality in the first week of the broiler's life. By depriving the embryo from its nutrients, bacterial infection of the yolk may lead to reduced survival rates.

If a bacterial infection does not lead to mortality, presence in the gastro-intestinal tract can, in several ways, lead to decreased growth. Bacterial toxic excretion products can damage the intestinal wall, hereby decreasing its ability to absorb necessary nutrients.

Decreased broiler growth also results from the competition between the bacteria and the broiler for these same nutrients in the gastro-intestinal tract.

Studies on broilers with other bacterially infected organs such as lungs, liver or kidneys have revealed that these might also contribute to lower body weights, higher feed conversion and higher mortality rates as compared with non-infected birds.

Early identification of flocks at risk requires availability of accurate indicators of dysbacteriosis which include, amongst others, a history of diarrhoeal illness or wet droppings and abnormal morphology of the intestine accompanied by watery fluids.

Leg problems resulting in lameness can be caused by bacterial infections. Infected birds will show changes in gait, might use wing tips for support and express vocalisations indicative of discomfort.

Next to obvious consequences for welfare, performance of birds with less severe symptoms will also be impaired due to decreased feed and water intake as compared with completely healthy birds.

Eventually, optimal hygienic conditions throughout the production chain should serve to guarantee pathogenic free production of broiler meat for human consumption. The necessary actions can be taken in both the breeder as well as in the broiler flocks.

Accurate management of the breeder flock to prevent dirtiness of hatching eggs increases the performance potential of the progeny broiler flocks. ■

Managing Perfection

The true benefits of perfect hatching eggs

by Erik Helmink, Vencomatic BV

Perfect hatching eggs are the start of a profitable broiler production. With small gains in egg quality, tremendous improvements can be made by means of output at the end of the production cycle.

With some simple attention to the points mentioned below, one can address possible problem areas on the road of the hatching egg, from the hen to the hatchery.

Egg hygiene

Egg hygiene is the key to prevent bacterial contamination. Hygienic eggs give a higher hatchability, less bangers in the hatcher and more healthy, saleable chicks. Especially at the point of lay, when the cuticula layer on the outside of the egg is still humid, bacteria can easily enter the egg. Therefore a hygienic nest surface should be provided. During egg collection and storage, the egg should only have contact with clean surfaces and the number of mechanical transfers should be minimised. Floor eggs and soiled eggs should not be placed in the setter, as these eggs are suspected to be contaminated.

Mechanical damages

Hatching eggs are valuable and should be handled with care, in order to keep the egg shell intact. Even small hairline cracks form an easy port of entry for bacteria and, in addition, they will pose a risk for dehydration. Possible damage can be caused by the birds or by rough collection. In order to protect eggs from damage by the birds, eggs should roll out of the birds' sight directly after lay. Mechanical damage during collection can be reduced by a high level of accurately adjusted automation and the minimum number of transfers of the eggs. On-farm egg packing and points down setting direct on setter trays gives an advantage, as this takes out extra transfer of eggs in the hatchery.

Storage and transport

Storage time and conditions, such as temperature and relative humidity, have their effects on the quality of the internal egg environment. Dependent on the storage duration, one should choose the right climate conditions. For storage up to three days, an egg temperature of 18-21°C is advised in order to arrest embryo development. It is wise to have a controlled on-farm storage for hatching eggs. Transport is equally important when looking at optimising hatching egg quality. Prevent transportation on bumpy roads and the use of shaking trucks, as rough transport will result in lower hatchability.

An example of the benefits of hatching egg perfection:

A Vencomatic customer recently showed me his results, after following our recommendations for his breeder house.

At a production of 172 eggs, his results showed 2% more settable eggs, because he collected less seconds. The results in the hatchery also improved with 1% higher hatchability.

Together with the extra eggs, this gave him, in total, 4.7 more day olds per breeder hen.

When we followed his chicks to the broiler house, we found an average of 0.5% less mortality in the first seven days. Meaning that, actually, we improved his results with 5.4 extra viable chicks per breeder hen! This shows the true benefit of perfect hatching eggs. ■