Improving hatchability after longer periods of egg storage

by Dinah Nicholson, Aviagen.

People working with poultry breeding stock expect hatchability to decrease when eggs are stored for longer than a week. Stored eggs will have a higher rate of embryo death between two and three days of incubation, and need longer to complete incubation. This leads to some live chicks being rejected at take-off because they hatch too late to be useable. The rate of hatch loss with each extra day of storage is variable, and depends on farm and egg storage conditions as well as flock health, age and breed.

Hatch after egg storage

Egg age at set in a commercial broiler hatchery can usually be controlled reasonably well, and the majority of eggs will be set within seven days of being laid. However, when market conditions are poor, or when order sizes are variable, longer periods of egg storage become unavoidable. Extended egg storage invariably causes lower hatchability, worse chick quality and poorer broiler performance.

During long egg storage (>7 days), a series of changes occur within the egg which contributes to deteriorating hatchability. The albumen pH increases and, as a consequence, its protein structure changes causing a loss of albumen viscosity. The yolk changes, as water passes by osmosis from the albumen into the yolk and the yolk membrane thins and weakens. There are also changes to the embryo within the egg. When the egg is laid the chick embryo has around 60,000 cells after developing in the hen's oviduct while the egg forms around it. As storage proceeds, the cells in the embryo start to die – up to 70% of the embryo cells may die by day 17 of storage.

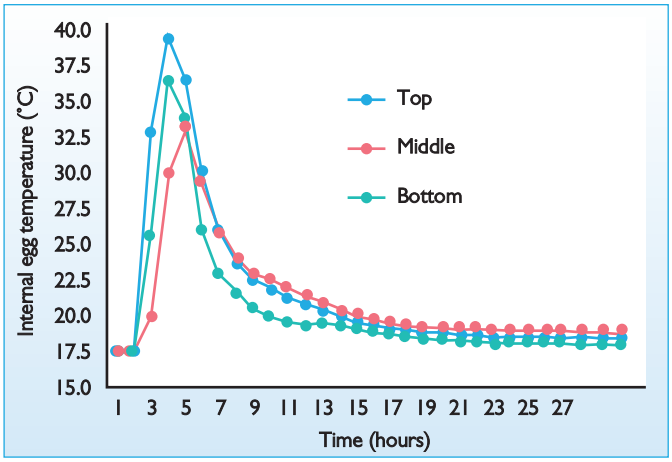
When storage needs to be longer than seven days, producers are advised to run their egg stores at a cooler temperature, which helps maintain albumen quality. For storage of more than 14 days, it probably helps to store the eggs upside down or to turn them twice daily on setter trolleys. This is on top of standard egg handling advice, which is to cool the eggs below physiological zero as soon as possible after they are laid, and then keep them at a constant temperature until they are moved to the setter.

When a hen lays a clutch of eggs in a nest, she does not always follow what is believed to be best practice. Her eggs are held at ambient temperature, which fluctuates through the day. Every time she sits on the nest to lay the next egg, the eggs that are already laid will warm up again.

She turns the eggs, but mostly as the result of getting into the nest to lay the next egg. Various research workers over the past 100 years have considered the natural environment of the fertile egg, and tested the effects of imposing various patterns of warming and cooling the eggs before or during storage.

Many, but not all, of these treatments have improved hatchability in stored eggs.

Fig. 1. Internal egg temperatures measured at three locations on the egg store trolley during the application of four hours of SPIDES treatment.



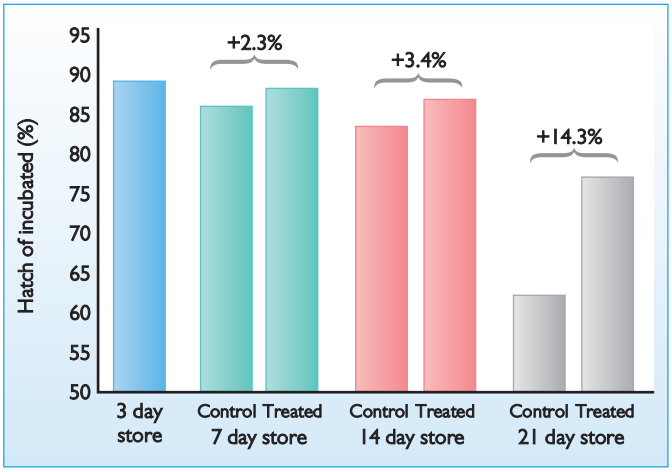


Fig. 2. The effect of SPIDES treated eggs stored for either 7, 14 or 21 days compared to untreated controls.

Reduce embryo cell death

Professor Amos Ar from the University of Tel Aviv suggested that embryo cell death during storage is a major reason for the poor hatchability of long stored eggs. He proposed that giving the eggs a short (less than six hours) period of incubation at regular intervals during long storage would allow the embryo to carry out cell repair and so reduce the rate of cell death.

Data from two experiments showed an improved hatch of eggs stored for 22 and 31 days when a single four hour period of incubation was given during the storage period.

An alternative approach has been to warm the eggs immediately before they are stored, with the objective of advancing their stage of development to a point that is better able to survive long storage.

At the University of Alberta, Dr Gaylene Fasenko's team showed that giving eggs a single short period (six hours) of incubation before the start of egg storage improved the hatch of 14 day stored eggs compared to untreated controls.

Eggs vary in their developmental stage when they are laid, but most of them will be at a stage just before the formation of a structure called the hypoblast. Fasenko and her co-workers suggested that eggs cope better with long egg storage if the formation of the hypoblast is complete but the embryo has not progressed to the stage called the primitive streak.

There are, however, some practical difficulties with heat treating eggs on the day that they are laid. Most commercial hatcheries transport eggs from the farm to the hatchery twice a week, so eggs are between one and four days old when they reach the hatchery. For an incubation treatment to be given on the day of lay, either the eggs need to be taken to the hatchery every day, or there needs to be an incubator on the farm. It would not be an easy process to manage.

Acknowledging the challenges inherent in applying pre-storage

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incubation to broiler eggs within a commercial operation, Aviagen has carried out a series of trials looking at the possible benefits of the technique of applying one or more short periods of incubation during egg storage (given the acronym SPIDES).

This can be imposed at a single location (the hatchery) which is already equipped with incubators and so is easier to implement consistently than a pre-storage treatment. The research is ongoing but the results achieved so far are promising.

Trials

The initial research was done in the hatchery at Aviagen's Albertville, Alabama, trial facility in the USA. In these early trials, eggs held on a storage trolley were taken directly from the egg store and placed in the corridor of an operating fixed rack multi-stage setter running at 99.5°F (37.5°C). The eggs were held in the setter for the required time (between 2-6 hours) before being moved back into the egg store operating at 63°F (17°C).

The treatment was applied to the eggs one or more times during the storage period.

Fig. 1 shows internal egg temperatures measured at different positions on the setter trolley during one cycle of SPIDES treatment applied for four hours. As only a relatively small number of eggs (typically 1,944) were used in the experiments, the eggs heated up quickly, although within four hours not all of the eggs on the trolley reached the incubator temperature of 99.5°F (37.5°C).

Once the eggs were moved back into the egg store they took several hours to cool back down to store temperature. Although there is some debate as to the exact temperature at which chick embryo cells stop dividing and growing (sometimes called physiological zero) it is thought to be between 75-80°F (24-27°C). From Fig. 1 it can be seen that although there was variation in temperature the eggs exceeded the lower end of the physiological zero range for at least four hours during a four hour treatment cycle.

Fig. 2 shows the results from one trial that showed a hatch improvement using the SPIDES technique for Ross 308 eggs stored for 7, 14 or 21 days. The seven day stored eggs were treated once on day four of storage, the 14 day stored eggs were treated three times (on days 4, 7, and 11 of storage) and the 21 day stored eggs were treated four times (on days 5, 10, 15 and 19 of storage), with a four hour treatment period on each occasion.

There was an improvement in hatch from the SPIDES treatment with all three storage periods and the longer the egg storage the better the hatch improvement. Other trials, looking only at 21 days of storage, have shown even larger hatchability gains due to the SPIDES treatment. It was encouraging that the SPIDES technique was beneficial even when the storage period was relatively short at seven days.

Follow up trials have been run in Aviagen commercial grandparent (GP) hatcheries in Europe, the USA, New Zealand and India. The initial experiments used Ross 308 or Ross 708 broiler hatching eggs, but subsequent trials with various GP line crosses and GGP lines have all given similar results. In most trials the SPIDES treated eggs were compared to untreated eggs that had been stored for the same length of time and also eggs from the same batch that had been set fresh, immediately after delivery to the hatchery.

The experiments have investigated the effect of applying the SPIDES treatment at differing frequencies during storage, time periods and storage times. To date 12 trials (three small scale and nine commercial scale trials) have been completed and in all but two of them the SPIDES treated eggs hatched substantially better than untreated controls.

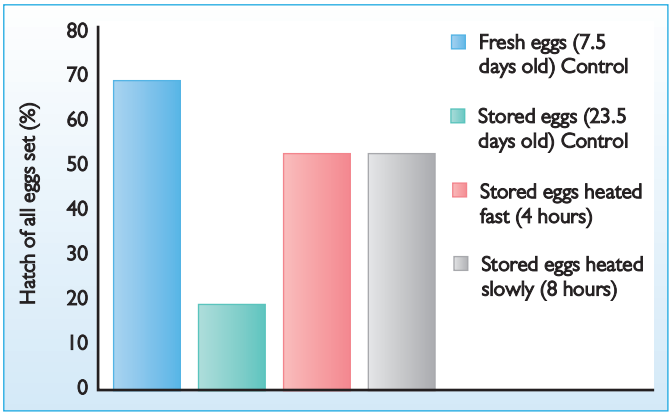

Fig. 4. Hatchability of eggs warmed fast (four hours) or slowly (eight hours) to incubation temperature four times during storage. Eggs were treated at 8, 11, 15 and days old.

The results from all trials can be summarised:

- The SPIDES technique improves the hatch of eggs stored between seven to 26 days.
- The treatment is effective if applied between one and four times during 21 days of storage, with 3-4 times giving the best results.
- The best results were achieved when treatment was applied for between two and four hours.
- A later trial showed that it is possible to go too far – six SPIDES treatments gave poorer results than three or four, and heating for six hours rather than two or four gave poorer results as well. In the most extreme treatment, which gave six repetitions of six hours incubation, very few of the eggs hatched.
- The SPIDES technique worked even if the internal egg temperature only reached 91°F (33°C). The best results were obtained when internal egg temperature reached close to 99.5°F (37.5°C), but this does not appear to be absolutely essential for the technique to work (see example in Fig. 1).
- To date, the SPIDES technique has been found to work with all types of broiler eggs tested, from different genetic lines and different breeder flock ages. There are also reports of the technique being successfully applied to commercial layer lines.
- The SPIDES treatment improves hatchability mostly by reducing embryo mortality during days 1-2 of incubation and to a lesser extent full term embryos that pip the eggshell but do not hatch.
- The SPIDES treated eggs hatch earlier than the untreated stored eggs and are closer in hatch time to the fresh untreated eggs. Egg storage normally delays hatch and it appears the SPIDES treatment reduces this effect.

Commercial application

The work at Aviagen is now focusing on how the SPIDES technique can be applied on a commercial scale. One of the early questions was whether the speed at which the eggs heat up is important. For example; a large single stage setter may take eight hours to warm all the eggs to incubation temperature.

Reassuringly, a trial run at Aviagen's UK parent stock hatchery showed that bringing the eggs up to incubation temperature slowly over eight hours was just as effective as a faster four hour heating period (Figs. 3 and 4).

Current studies are investigating the optimum heating time and frequency when applying the SPIDES treatment on a commercial scale.

Aviagen is also collaborating with Dr Murray Bakst (USDA, Maryland) to understand the underlying biological effects of the SPIDES treatment. Aviagen hope to discover if hatchability improvement achieved using the SPIDES technique is a consequence of the embryo cells repairing the damage caused by long storage or through advancing the stage of embryo development.

Understanding the biological basis will make it easier to implement the technique commercially and Aviagen believe it will be of considerable interest to the industry ■

Fig. 3. Egg shell surface temperatures, showing the temperature profile of fast (four hours) and slow (eight hours) warming. The treatments were repeated four times before the eggs were set aged 23.5 days.