What does the future hold for commercial broiler incubation?

Over the last 20 years the hatchability of broilers has improved significantly: an analysis of over 18,000 Ross 308 parent stock flocks from across the globe hatched between 2000 and 2018 shows an annual hatchability improvement of around 0.4% per year (Fig. 1).

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This is in addition to the large gains in both broiler performance and welfare made over the same time period and disproves the mistaken stereotype that, as primary breeders select for more boiler growth, it results in reduced breeder and hatch performance.

Primary breeders use balanced selection techniques to ensure that they can select for antagonistic traits at the same time as making improvements in all aspects of breeder, broiler and welfare performance.

Much of the hatchability gain over the last 20 years is due to genetic selection, but there have also been significant improvements in the design of incubators, and the management of the incubation process within hatcheries. Much of the improvement in incubation technique is a better understanding of how to control incubation temperature through monitoring eggshell temperature.

Research has shown that maintaining an optimum eggshell temperature of 37.5±5°C throughout the incubation period improves hatchability, chick quality, and post-hatch performance (Fig. 2). There is a gathering volume of research showing that incorrect eggshell temperature has many negative impacts on the proper development of the embryo, affecting long term performance post-hatch.

A consequence of the research on incubation temperature has been the development of tools to monitor eggshell temperatures within commercial incubators in order to ensure proper control. The use of tools such as infrared thermometers, cameras, and data loggers allows the hatchery manager to maintain the correct temperature profile and identify issues causing temperature variation within the incubators (Fig. 3). Another development is that some incubator manufacturers have now incorporated sensors within their machines to continuously measure eggshell temperature and use this to control the operating temperature.

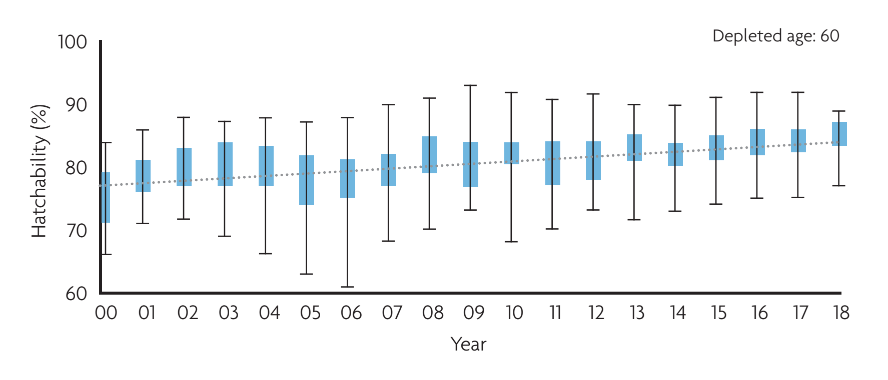

Fig. 1. Improvement in the broiler hatchability of eggs from Ross 308 parent stock flocks hatched between 2000 and 2018.

Do we need to incubate the modern broiler differently?

It has been suggested that the modern broiler produces an egg that requires a lower incubation air temperature because selection for faster post-hatch growth has resulted in an embryo that grows faster and produces more metabolic heat.

The scientific evidence does not really support this theory: a comparison of studies over several decades does not show that metabolic heat output has increased. This is perhaps not a surprise as over the same period of incubation, egg size or eggshell porosity (controlling oxygen uptake) have not changed.

The total heat production from the eggs within an incubator will increase as egg size increases with flock age (larger eggs produce more heat) or as fertility improves. Currently, research is ongoing as to the possible benefits that short periods of either hotter or colder incubation temperatures may have on post-hatch performance, normally referred to as thermal manipulation.

Studies in Israel have shown gains in FCR and breast meat yield from short periods of elevated incubation temperature applied daily after day eight of incubation. More work is needed in this area, particularly in large scale commercial incubators to confirm the scientific studies in small incubators. One of the challenges will be controlling incubation temperature accurately and uniformly in large machines to apply the treatments correctly. If this can be done, there may be commercial benefits in the future for thermal manipulation.

One area that has lacked much research until recently is determining the optimum environment during the hatching process. Currently, a wide range of environments are used to hatch chicks, all of which can achieve good results. Some hatchers only use air cooling; as a consequence, the machine has a high ventilation rate, resulting in low humidity and low carbon dioxide (CO_2) levels.

Other hatchers use water cooling with a much lower ventilation rate, allowing better uniformity of temperature within the machine, particularly in larger hatchers. However, the humidity and CO_2 levels are much higher. Indeed, in some hatchers, a short period of high CO_2 (~1%) is used to stimulate the chicks to hatch together.

At the other end of the spectrum, some companies hatch the chicks very successfully directly in the brooding house where only temperature is controlled. It all begs the question – how important is the hatching environment?

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Research is now starting to investigate the hatching environment, focusing mainly on temperature and CO_2. Initial results from these studies suggest that eggshell temperature during the hatching process should be 36.7-37.8°C. There is only limited evidence that CO_2 is important in normal hatcher operation: levels of 1% advanced internal pipping time, and 4% increased both internal pipping and hatch time.

One study also showed a larger heart size at 1% CO_2, but it is not known if this has any long-term consequence for the chick. The level of humidity in the hatcher has not been investigated at all, although given that hatchers with both very low and high humidity perform successfully, it seems unlikely that humidity is very important. What is clear is that we need a better understanding of the optimum hatching environment and methods for monitoring the environment experienced by eggs and chicks.

Another topic relating to hatching, which is receiving a lot of attention both commercially and in research, is the benefit of providing food and water to broiler chicks immediately after hatching from the eggshell. This can be done by providing both feed and water in the hatchery or hatching the chicks directly into the brooding house. Both techniques are being used, but more research is needed into the effect of transport of broiler chicks after they have received feed and/or water.

An additional technology which has the potential to have a major impact on the hatchery is embryo sexing and detection. Tools are being developed that will sex embryos in the first few days of incubation, will detect whether the embryo is viable and will even measure how fast it is developing in order to be able to accurately predict hatch time. If these technologies are successful they will be able to:

- Reduce the requirement to hatch unwanted male chicks in the layer industry.
- Improve broiler uniformity by placing chicks of a single sex and close hatch time.
- Reduce bacterial load in the hatchery by removing non-viable embryos and rots before they can spread contamination.
- Reduce in-ovo vaccination costs.

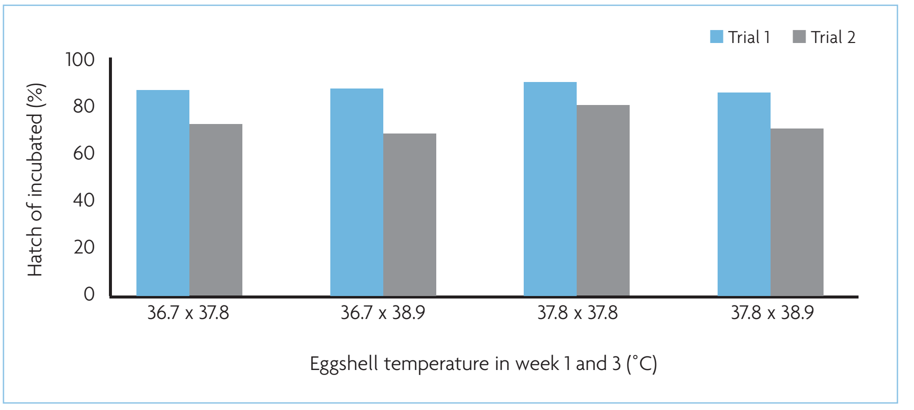

Fig. 2. The effect of eggshell temperature during the first and third week of incubation on hatchability (Lourens et al, 2005).

With all the embryo detection technologies, there are significant commercial issues to be resolved, including cost and benefit, the ability to screen a large number of eggs, and accuracy. However, if these issues can be resolved, the possible benefits to the poultry industry could be huge. Finally, an area that will become more and more important in hatcheries going forward is the use of 'big data'.

What is big data?

Today we collect data on hatchery performance, the performance of the broilers on the farm, data on the breeder flocks supplying the hatchery and from the equipment in the hatchery (temperature, humidity, ventilation rates, room pressures etc). All this data can be brought together and analysed using statistical modelling to understand which factors affect both hatch and post-hatch performance, allowing hatchery managers to fine tune incubation environment and management.

Importantly, the statistical model can predict the consequence of making a change in management so the cost and benefits can be properly calculated. The models can also be used to predict future performance to allow for better planning.

The main challenge for data analysis is having the correct expertise. Database programmers are required to handle large quantities of data, check it for errors, and be able to connect data from different databases. Statisticians and mathematicians are needed to model sometimes complex, continuous data that includes effects that change in importance depending on the length of time an event occurs. For example, if an egg is cooled to 30°C for several hours during incubation it will have minimal or no consequence for hatch, but if it occurred for several days it would be a disaster.

The issue in many poultry companies is that they do not yet have people with the correct skills for the type of data analysis that could be done. However, companies that make the investment in analytics are going to reap the rewards in the future.

Today, most broiler hatcheries are doing an excellent job and achieving very good results. The future will see a continual fine-tuning of the incubation environment to improve, not so much hatch, but post-hatch performance. The hatcher environment is an area which needs more research to understand what is and is not important for producing a good quality chick. The ability to sort embryos by sex, viability, and rate of embryo development through the use of new technologies has many exciting possibilities for the future

Finally, the use of data analytics in the future will become more important in all aspects of poultry production, including hatcheries. I look forward to seeing what happens in the future. ■

Fig. 3. Monitoring eggshell temperature using (a) an infrared ear thermometer, (b) a thermal imaging camera and (c) dataloggers.