Maximising chick uniformity,

Healthy, vital day-old chicks are the basis of success for any hatchery operation. The success of each hatch can be actively manipulated while the embryo is still in the egg. Opportunities to control the hatchery's output can have significant impact on the resulting broiler.

By Dr Marleen Boerjan, *Pas Reform Hatchery Technologies, Zeddam, The Netherlands*

The poultry industry has undergone major changes since the late 1960's, with genetic selection and highly developed management practices greatly improving the efficiency of meat and egg production. These changes have resulted in the development of highly specific selection programmes, which are reflected in today's industry by the growth of distinct specialisations for the production of either broiler or layer chicks.

It is becoming increasingly obvious that meat and egg producing birds differ in physiology to such an extent that their respective embryos need very specific and differing incubation conditions. This factor is well illustrated in studies undertaken by Pas Reform in conjunction with the Humboldt University in Berlin in 2003, which found that based on embryonic oxygen consumption, Ross 308 embryos produce around 26% more metabolic heat than embryos from a traditional meat producing breed.

As a consequence of increased metabolic heat production in these new breeds, it is of vital importance that the temperature set points and cooling capacities in a commercial incubator, often containing 100,000 broiler eggs, are set appropriately. This avoids a build-up of unacceptable temperature levels, which can indeed be detrimental to the health of the developing embryo.

(a) Red beak

(b) Red hocks

The vitality of individual chicks can be described using different aspects of chicks' morphology. These morphological criteria have been used to develop the Pasgar score and a more detailed scoring system developed by scientists from the Catholic University of Leuven (Belgium).
Poor incubation conditions result in badly closed navels, abnormally developed beaks and legs. Yolk sac extruded from the navel can be the result of high temperatures combined with high humidity. Red beaks(a) and red hocks(b) point to high temperatures in the setter and hatcher.

Incubator climate

The role of the incubator climate on the development of the chick and, thus, the vitality and performance of the chick post-hatch, is highly significant. Embryonic development is a continuous process with typical accents on cell differentiation, followed by the growth and maturation of the organs and physiological control systems in the later phases of development.

Here we focus on the last 'maturation' phase of chick development and its impact on chick vitality and uniformity in hatchlings.

During the maturation phase, the organs become responsive to specific signals such as heat or cold stress; the absolute growth of the embryo is decreased - and growth rate is inversely related to temperature.

A fully developed thermoregulatory system is essential for the maintenance of a constant body temperature, even under heat or cold stress inducing conditions. During the escape from the egg, the metabolism of chicks switches from lipid digestion to carbohydrate and protein metabolism – a transition that to be successful relies entirely on the capability of the fully matured digestive tract. Once hatched, it is important to understand the status of the new chick, and for that reason, this paper also describes methods to evaluate the vitality of individual chicks as well as introducing definitions of uniformity for batches of hatchlings.

Matured thermoregulation

A vital day old chick is an active chick that has the physiological potential to grow at the best rates with the lowest feed conversion rates. Vitality is the result of optimum differentiation, growth and the maturation of all organs and physiological controlling circuits. The process of maturation starts shortly before hatching, the so-called peri-natal period, and continues during the first week post-hatch.

It has been shown that during this short time window, the emerging chick is

performance and vitality

Figure a - 10% uniformity=100% mean weight 42.2 g +/- 10% (38.0-46.5)

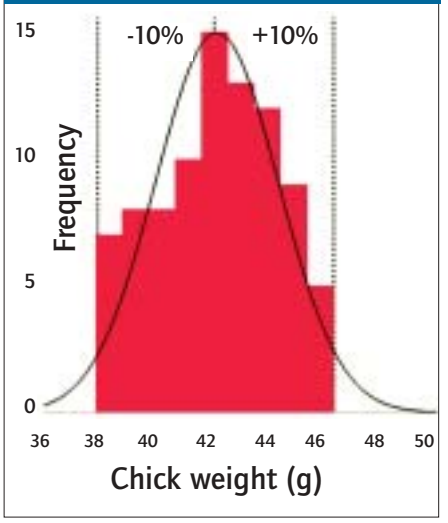

Figure b - 10% uniformity= 88% mean weight 42.2 g +/- 10% (38.0-46.5)

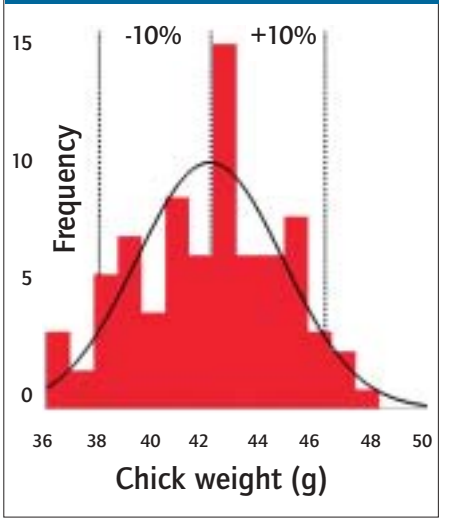

Figure c - 3% uniformity=87% mean length=19.5 cm +/- 3%=(18.9-20.1)

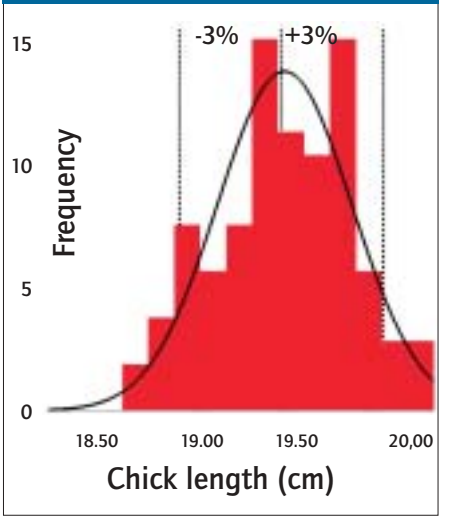

Figure a,b and c. The greatest challenge for the modern hatchery is to produce uniform chicks of high vitality, to achieve the highest growth rates and lowest mortality and feed conversion rates. Day old chick uniformity can be expressed as the percentage of chick weights that fall within 10% of the average chick weight per batch, as shown in (a) and (b). Day old chick uniformity can also be expressed as the percentage of chick length that falls within 3% of the average chick length per batch, as shown in (c).

equipped to cope, within certain limits, with the acute change in environmental conditions. In recent years, significant research has been undertaken on the development of the thermoregulatory system of the chick embryo and hatchling. This research has shown that with the development of the thermoregulatory system, the hatchling develops the capability to maintain its body temperature under changing environmental temperatures. Changes in incubation temperature at the end of embryonic development induce epigenetic adaptation, which results in a post-hatch long-lasting cold or heat adaptation.

In addition, hatchlings can be physiologically manipulated to better tolerate heat stress, by short-term exposure to mild heat stress (36-37.5 1°C) until day 3 post hatch. Subsequently, these treated chicks are thermally conditioned and show the highest growth rates with low feed intake and higher feed efficiency at 42 days of age than chicks that have not been conditioned in this way.

The maturation of the thermoregulatory system during the first week also includes the development of the regulation and response of heart rate baseline to changing environmental temperatures. By adapting the incubation environment throughout the last phases of incubation, we can manage the embryo's ability to regulate body temperature while it is still in the egg.

Matured digestive system

Alongside the development of competence to regulate body temperature, full maturation of the digestive tract is equally essential for broiler performance. Before internal pipping at the nineteenth day of incubation, the embryo begins to draw the yolk sac into its body - and by the end of the twentieth day in the egg, the entire yolk sac has been absorbed. The lipid-rich residual yolk content serves as an important energy source for the day old chick and will continue to be a major source of energy during its first days of life.

The residual yolk sac is known to be essential for the maturation of the digestive tract and maturation of energy metabolism. The growth of the embryo depends primarily on the utilisation of yolk lipids - and thus lipid metabolism continues after hatching, to be gradually replaced by the capacity to use carbohydrates and proteins.

The Japanese researcher Murakami (1992) and colleagues showed that the removal of the yolk sac delayed growth by two days for at least seven days when compared with control chicks, mainly because of slower development of the digestive tract. Also, the development of the gastro-intestinal tract lags behind under fasting conditions, which may support the belief that food intake in the first days after hatching actively stimulates yolk utilisation. Today, we have the ability to manage embryos inside the egg, to the extent that yolk-sac absorption can be controlled to various levels up to the moment of hatch.

From these fundamental physiological studies, it is clear that the differentiation, growth and maturation of the broiler chick is a continuous process, starting as the temperature of the egg rises to 37-38°C (98.6-100.4°F) and continuing during the first week of hatching. The main body functions mature during this 'sensible' phase, such that the adult chick can adapt to environmental changes.

In practice, this means that the broiler industry can manage and predict efficiencies in growth and feed conversion by carefully managing conditions in the incubator, with the ability to actively manipulate outcomes by controlling conditions while the embryo is still in the egg, for optimum post-hatch performance.

Chick vitality

Along with the maturation of the thermoregulatory system and the digestive tract, the growth and maturation of the individual embryo has been shown to be highly dependent on incubator conditions. For optimum hatchability and chick vitality, eggshell temperature for each egg in the incubator should follow a natural pattern within a range of 37.6-37.9°C (99.7-100.2°F) during the first two-thirds of incubation, and 38.1-38.8°C (100.6-101.8°F) during the last days in the setter. Within this natural pattern, minor changes in eggshell temperature induce different growth rates, which can be used to manage chick development in the egg - in order to adapt the incubation to embryonic needs of different broiler breeds. In the hatcher, temperatures higher than 39.5°C (103°F) must be avoided because they induce increased late mortality and slower

post-hatch broiler growth compared to lower 38.3°C (101°F) hatcher temperatures. In addition, constant exposure to high temperatures will adversely affect normal maturation and hatch, producing many stunted chicks with poorly closed navels and red hocks.

Daily hatchery practice shows us that poor incubation conditions result in poorly closed navels and abnormally developed beaks and legs. In collaboration with Wageningen University and Research centre, Pas Reform's studies have shown that broiler chicks with red hocks develop significantly more leg problems at 30 to 40 days of age.

It is clear that the vitality of an individual day old chick can be described using different aspects of the chicks' morphology. These morphological criteria have been used to develop the so-called Pasgar score and, separately, researchers from the Catholic University of Leuven in Belgium have developed a more detailed score for chick vitality.

In both scoring systems, chicks lose points from a total of 10 (Pasgar score) or 100 (Leuven score) for abnormalities seen in navels, beaks, legs and yolk sac volume.

The Pasgar score has proven its worth in current hatchery practice – and because it is easy to teach to hatchery personnel, is currently in widespread use to improve incubation programmes around the world. The Leuven score includes greater differentiation for degrees of deviation from normal for each of the criteria used. Using this scoring system, researchers from Leuven University have shown that, within one batch, chicks with scores of 100 produced significantly higher relative growth than that of chicks with quality scores less than 100.

Maximising uniformity

We have seen how various physiological systems can be manipulated to influence chick vitality. In reality, today's commercial hatcheries must deal with hundreds of thousands of broiler embryos – each developing, growing and maturing in one incubator.

While the Pasgar and Leuven scoring systems are used to describe the vitality of *individual* chicks and batches of chicks when representative samples are scored, uniformity in each *batch* of day old chicks is of equal and fundamental importance to commercial success.

The greatest challenge for the modern hatchery is to achieve uniform flocks of high vitality chicks. It is generally understood that a batch of poor quality chicks, combined with poor farm management, will result in unacceptable variations in bird size or low uniformity in the flock. Poor flock uniformity puts immense pressure on farm management, who to maximise the performance of their operations, must deliver high quality birds while simultaneously keeping feed conversion rates as low as possible. Good uniformity makes it possible to manage the flock to a lowest mortality and feed conversion.

Training and consulting activities in Pas Reforms' Academy have taught us that hatchery managers need an objective measure for uniformity, to predict performance at the farm.

Despite the fact that maternal age and incubation conditions, like temperature and humidity, influence both the weight and the length of the chick – we subscribe to the use of weight and chick length as a viable measure of uniformity. Analysis of our research data, based on these criteria, has lead us to conclude that both chick weight and chick length are applicable, because uniformity is based on the variation and not on the absolute values.

In broiler production, uniformity is expressed as the percentage of birds whose weight falls within 10% of the flock's average weight (*Figure a, b and c*) – and current industry standards dictate that to achieve good uniformity, 80–85% of birds must fall within 10% of the average flock weight. We have found that for certain batches of chicks, 100% uniformity based on chick weight is possible, when uniformity is defined as the percentage of chick weights that fall within 10% of the average chick weight in a batch of hatchlings. Our preliminary research has shown that uniformity based on chick weight may also be used to predict mortality in the first week.

Total chick length may also serve as a useful parameter for a uniformity test – although we have found that in measuring the total chick length from the tip of beak to the toe, differences of 0.5-1.0 cm can arise when different people measure the length of the same chick. In any case, Pas Reform's research is leading to the conclusion that to apply uniformity scores based on chick length, a 3% range from the average is advised, to achieve viable, measurable differences.

Conclusions

- *Managing the embryo in the egg:* The process of maturation starts shortly before hatching and continues during the first week post-hatch. In this short time window, the chick is equipped to cope with the acute change in environmental conditions. The maturation of the thermoregulatory system and the digestive tract was described, whereby the thermoregulatory system matures through changes in incubation temperature at the end of the embryonic phase – and maturation of the digestive tract is facilitated by the absorption of the residual yolk sac.
- *Hatch spread:* If temperature distribution does not meet the requirement for each individual egg – and therefore each individual embryo - placed in the incubator, then the embryos will grow at different rates, resulting in a large spread of hatch. Incubators must be designed and calibrated to simulate a hatching period that is as close as possible to the natural variation in the incubation length of broilers.
- Vitality of day old chicks can be optimised by scoring morphological criteria. The Pasgar score has proven its worth in current hatchery practice worldwide. Chicks with red hocks are at risk of developing leg problems at 30-40 days of age. Researchers from Leuven University have shown that chicks with scores of 100 on the Leuven score grow at a significantly higher rate than those with scores of less than 100.
- *Uniformity:* From preliminary research, Pas Reform has concluded that uniformity based on chick weight can be used to predict mortality in the first week
- Day old chick weight and length can be used as a measure of uniformity, because uniformity is based on the variation and not on absolute values
- Day old chick uniformity can be expressed as the percentage of chick weights that fall within 10% of the average chick weight. Day old chick *uniformity* can be expressed as the percentage of chicks whose length falls within 3% of the average chick *length* in the flock.
- Day old chick vitality combined with *uniformity* in a batch of day old chicks is a prerequisite to optimum farm management and achieving the lowest possible feed conversion rates. ■

Epigenetic adaptation

All living organisms must deal with fluctuating environmental conditions. The day old chick, for example, has to learn how to maintain body temperature at the right level while temperatures at the farm vary between 25-40ºC. Epigenetic adaptation, first formulated by Wolff (1759), is an adaptation to an expected and changing environment. The day old chick can adapt to higher farm temperatures after an early experience during the so-called 'sensible' phase. Epigenetic adaptation occurs during the latest phases of embryonic development and during the first days after hatching. In these short time windows, or what are known as the sensible phases, control systems like the thermoregulatory system are determined for the life of the bird by various internal and external (epigenetic) factors. Epigenetic adaptation is not fixed by the genes, but predominantly causes a permanent change in gene expression.

Hatch spread

If temperature distribution does not meet the embryo requirement for each egg placed in the incubator, the embryos will grow at different rates resulting in a large spread of hatch and, consequently, a spread in chick weights: chicks that hatch early lose weight due to dehydration. Incubators should therefore be designed to simulate a hatching period close to the natural variation in the incubation duration of chicks.