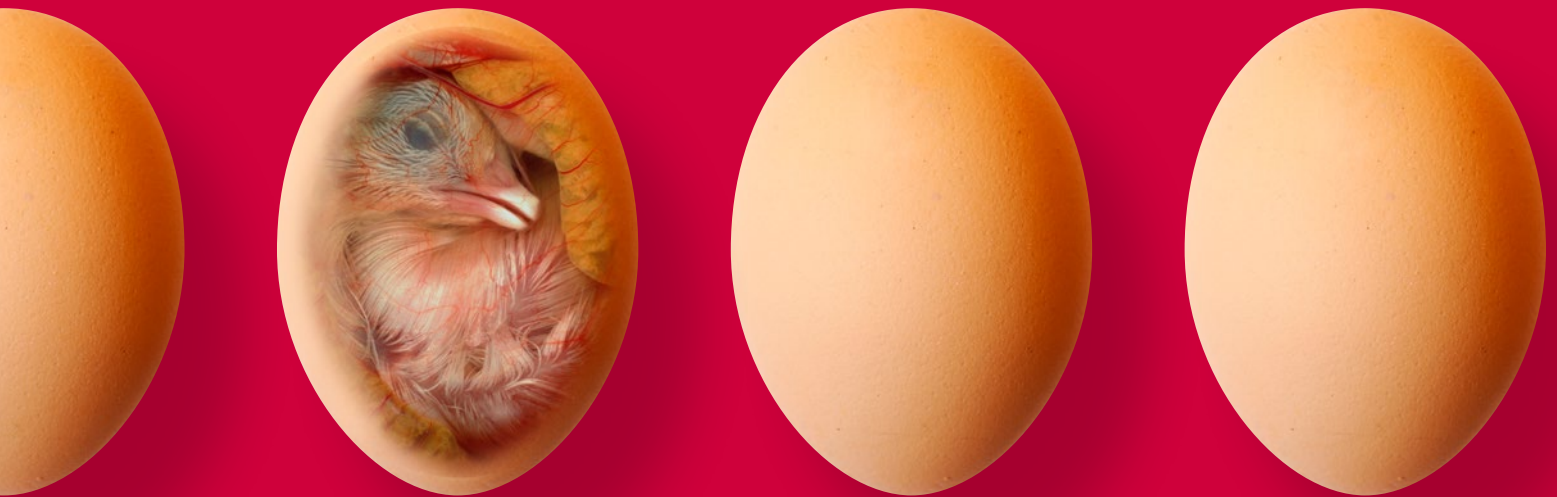


Pas Reform Academy

Putting science into practice



2nd Edition | Including 21 day embryo development poster



Pas Reform
Hatchery Technologies



Introduction

For more than 30 years, Pas Reform has studied the needs of the growing embryo, to understand the impact of genetic advancement on the performance of modern poultry breeds in incubation.

The forefront of scientific understanding combines with more than 90 years of hands-on hatchery experience, to meet new and emerging challenges in the modern hatchery.

This 2nd Edition of articles published by Pas Reform Academy, answers 52 of the questions more frequently asked by hatchery managers worldwide – in a single volume for easy reference.

Covering a diversity of hatchery-management related topics, from data analysis to fertility; optimizing weight loss to preventing omphalitis, each article incorporates the latest data, to give hatchery managers easy reference to the latest insights for best practice and optimized performance.

If you cannot find what you are looking for, or would like more detailed information on any hatchery-related topic, please contact us. We will be pleased to help.

Optimizing poultry production from egg to chicken

Hatching egg quality and incubation conditions influence broiler performance. It is therefore important to continually optimize every stage of incubation management, based on specific protocols for quality control and best performance.

In addition to data collection and data analysis, open, regular communication between breeder farm, hatchery and broiler farm is essential, both for quality control and to produce first-class results in integrated poultry meat production. The hatchery is a natural hub for communications between separate production links, because hatchery management receives production data both from the breeder farm and the broiler farm.

The basis for optimization is found (1) in quantifiable criteria and (2) in references or standards for each of these criteria (see table).

Reference data may be based on general standards provided by incubation consultants or breeder companies. Highly practical references are usually provided by the hatchery itself. Hatchery managers generally collect data on egg quality, fertility, hatchability and first-week mortality per batch of eggs – and from this data, hatchery specific standard curves can be produced.

Optimization protocols are then directed to perform above the hatchery specific standards. A disadvantage of hatchery specific standard curves is that structural failures and mismanagement may be hidden and not found. For this reason, it is still advisable to compare hatchery specific data with more general reference data from consultants or companies periodically.

Step in incubation	Quantifiable criteria:
Egg handling at the farm and during transport	<ul style="list-style-type: none"> – temperature and relative humidity at the farm and during transport; egg temperature on arrival (use portable dataloggers) – flock specific data: strain and age, lay%, health status – percentage of first class hatching eggs – percentages of dirty eggs, floor eggs, cracked eggs and eggs with hairline cracks, upside down eggs
Egg storage	<ul style="list-style-type: none"> – temperature and relative humidity
Preparation for incubation: egg traying, prewarming, preheating	<ul style="list-style-type: none"> – flocks age and length of storage – average egg weights and coefficient of variation (CV) – temperature and duration of preheating in the setter (or of prewarming in the setter room)
Incubation in the setter	<ul style="list-style-type: none"> – start of incubation and time to reach the temperature set points – incubation program (temperature, relative humidity, ventilation profiles) – egg weight loss
Transfer to hatchers	<ul style="list-style-type: none"> – incubation time at moment of transfer – percentage of clear eggs – results of break-out of clear eggs
Incubation in the hatchers	<ul style="list-style-type: none"> – hatchery climate (temperature, relative humidity, ventilation profiles) – time point increase of humidity and maximum level of relative humidity – time point of first chicks – time point of chick collection – hatch window
Chick collection	<ul style="list-style-type: none"> – total number of saleable chicks – percentage culled – average chick weights and coefficient of variation (CV) – chick yields (ratio chicken body weight and initial egg weight) – chick quality expressed in Pasgar-score units
After chick transport and first week at the farm	<ul style="list-style-type: none"> – temperature during transport measured with small data loggers – number of dead chicks upon arrival at the farm – weight of chicks upon arrival – percentage of dead chicks at day 7 – weight of chicks at day 7 – relative growth during the first week
Medication	<ul style="list-style-type: none"> – at the breeder farm – vaccination day old chicks before delivery

Advice

- Record key data on specific forms designed for this purpose.
- Record information on medication at breeder farm and hatchery, including vaccination.
- Define hatchery standards with reference to egg quality, hatchability, chick quality and first-week mortality.
- Compare data from each batch with the hatchery's own reference data.
- Regularly compare hatchery specific data with more general reference, for example from consultants or breeder companies.
- Take appropriate action if quantifiable data falls below reference data.
- Investigate for structural failures if hatchery specific standards deviate below the standard curves provided by consultants or breeder companies.
- Always evaluate the results of any measures taken to improve or alter standards.

2

Data analysis: a critical path to improved hatchability

In most hatcheries, the routine monitoring of incubation is based on data collected at each stage in the process. This is an important element of specific protocols for quality control and the optimization of hatchery results. For each step in the incubation process, quantifiable criteria have been defined. The hatchability of eggs set is one such quantifiable criterion, defined as the number of saleable chicks hatched from the total number of eggs from a certain batch/flock loaded in one or more incubators. For each age group, hatchability based on eggs set is used to determine an internal standard/reference for that group. The internal standard is a benchmark that allows the evaluation of:

1. overall differences and variation in hatchery results
2. the influence of flock origin on the variation of hatchery results; and
3. the influence of storage on the variation of hatchery results.

This article focuses on variability in the hatchability of eggs from one breed, delivered by different breeder farms to the same hatchery. The ultimate aim is to reduce variability between breeder farms and thereby optimize hatchery results overall.

The hatchability of eggs set is dependent not only on breeder farm management, but also on hatchery-related factors, such as storage conditions or incubation programs. Our analysis is based on data collected over several years, from different flocks incubated at one specific hatchery. With only one breed-type to consider, we can assume that factors related to incubation management are averaged for all flocks and breeder farms throughout the recorded period. We may also therefore assume that in the following example,

the main cause of variability is related to breeder farm management, including egg handling at the farm and during transport.

In a comparison of hatchability data from two farmhouses '1' and '2' (figure 1), eggs were received and incubated at a specific hatchery, using standard incubation protocols.

The graph in figure 1 shows that hatchability of eggs produced by farm 1 is below the standard (overall average hatchability), except for flocks aged 41-45 wks. Conversely, the hatchability of eggs received from farm 2 (figure 1), incubated in the same hatchery using the same incubation protocols, deliver above average hatchability (grey bars) for all flock ages.

The results suggest that farm 2 pays greater attention to optimizing breeder farm management and egg handling, both at the farm and during transit. With such attention to these factors, farm 1 could increase its total number of saleable chicks and improve hatchery performance and results overall.

Advice:

- Define a hatchery specific standard based on the average hatchability of eggs set per age group.
- Routinely apply quality control to eggs received from every farm supplying the hatchery.
- Compile and use a troubleshooting list.
- Reduced hatchability can be expected if eggs received are of poorer quality: poor shell quality and hairline cracks, more dirty eggs, a higher number of floor eggs and eggs placed sharp-end up, for example.
- Include candling and break-out procedures (e.g. 10 day candling) as standard. This will routinely identify and/or discount reduced true fertility or increased early mortality as causes of variation in hatchability.
- Communicate the results of your investigations with the breeder farm manager, as an important start to identifying the cause of below average hatchability results.
- Evaluate the effects of modifications to management practice on the hatchability of eggs set.

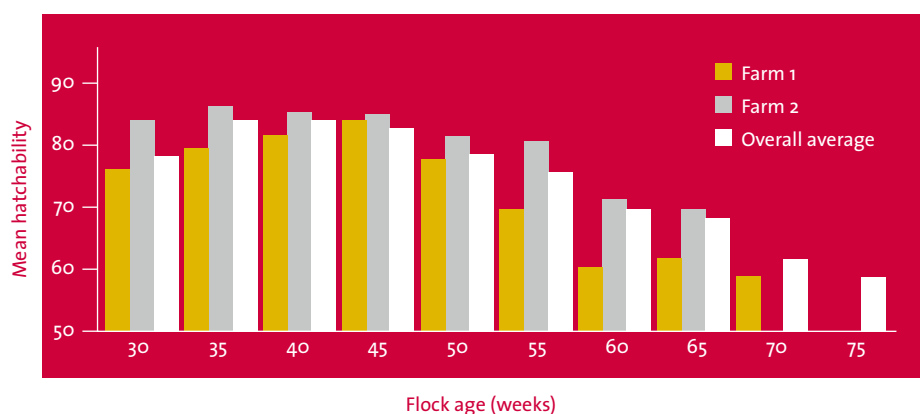


Fig 1. Percent hatchabilities of eggs (stored less than 8 days) from farm 1 and farm 2 compared to the overall average .

3

Hatching egg quality



Hatchability and chick data are the most important references for optimising incubation management. The age of the flock, number of storage days and incubation program are typically included in the analysis and optimization of hatchery results, but very often, insufficient attention is paid to the quality of the hatching eggs. While external quality is usually considered, there is much debate regarding internal quality control on a regular basis.

Egg quality in the broadest sense has been affected by genetic selection, for production traits like growth, feed conversion, number of eggs and egg shell quality. Breeding companies generally pay less attention to egg parameters related to hatchability and chick quality, which has led to increasing variability between batches of hatching eggs.

Ongoing research shows that genetic selection for production traits makes high demands of breeder management with respect to feed composition and feed restriction management. Genetic selection has influenced egg size, the yolk:albumen ratio and shell quality.

Feed restriction management influences the development of the reproductive tract and the nutrients available to the growing embryo from yolk and albumen. In addition, with the management of breeders becoming more complicated, the risk of stress, aggressive males and overcrowding has increased - with inherent consequences for egg (embryo) quality.

In conclusion, if specific protocols for optimizing incubation management are used, it is necessary to evaluate hatching egg quality on a routine basis. A brief summary of internal and external parameters is presented hereafter.

Egg shape

A good quality hatching egg has a blunt side containing a small air cell and a clearly recognizable sharp end. Too many abnormal or misshapen eggs signifies immaturity of the shell gland, young parent stock, disease, stress and overcrowding in the flock.

Egg shell

High quality hatching egg shells are smooth, without ridges or small lumps of calcified material (pimples). The colour of eggs within a batch is uniform. Young flocks produce eggs with thicker shells and when the flock ages, the shell becomes thinner and the incidence of abnormal shells increases. Insufficient calcium or vitamin D3 content in feed will produce thin egg shells. Saline drinking water and high levels of chlorine will also cause shell-quality problems. Abnormal white, thin-shelled eggs may indicate a variety of diseases (IB, NCD, EDS).

Albumen

Good quality hatching eggs contain a higher proportion of thick, viscous albumen with less thin albumen. The volume of thick albumen reduces with increased flock age and after storage. Good quality albumen is translucent with a greenish or yellow cast indicating the presence of riboflavin. Meat or blood spots point to stress or overcrowding in the flock.

Yolk

The size of the yolk increases with flock age and thus the ratio of yolk to albumen increases. In good quality hatching eggs, the yolk has a uniform colour without any blood or meat spot. Mottled yolk points to stress in the flock.

Embryo

The embryo floats on top of the yolk. In the un-incubated egg, the embryo is visible as a doughnut-like opaque ring with a translucent centre. A good quality embryo is 3-5 mm in diameter.

Advice

- Do not take egg quality for granted when optimizing hatchery economics.
- Use specific egg quality forms to record the quality of each batch of eggs received at the hatchery.
- Record the number of good quality eggs and the number of eggs not fulfilling required standards for every batch of eggs received.
- Take a minimum sample of 10 eggs to record the quality of the embryo, albumen and yolk.
- Communicate openly with your egg supplier regarding egg quality, with the mutual aim of improving and/or maintaining quality.



4

Uniform eggs are laid by uniform hens



Uniformity in day-old chicks is increasingly important as a contributor to economic efficiency.

Producing chicks of a uniform size requires two basic conditions: an optimized incubation process, which depends on the quality of the incubators and the incubation programs - and uniformly sized hatching eggs, which relies upon many factors linked to the breeder farm. Breed, the age of the hen, the hen's body size, feeding, diseases and the farm environment are all key factors.

In the hen's life cycle, egg size changes according to a natural pattern, being smaller at the beginning of lay and becoming larger towards the end. From the breeder flock, we expect the production of as many hatching eggs as possible in an optimum size range of 50-70g. If the hens are uniform in size and maturing at the same age, we can expect eggs laid by them to be uniform. Physical and physiological development depends mainly on rearing. In all management guides, body size is described by body weight. However the reproductive physiology of a small, fat hen is different from her tall, skinny sister - even if their body weight is identical. Actual body size is related to the dimensions of skeleton. Breeders within one flock that are uniform by skeleton size and body weight at 20 weeks will respond similarly to programs that stimulate maturity.

Because the skeleton is fully formed by 11-12 weeks of age, the first half of the rearing period becomes an important phase: a limited period during which uniformity can be successfully influenced. The first rearing week is the period when the most intensive growth in a hen's life occurs – potentially leading to great

differences between birds. These differences are mainly a reflection of variation in the development of internal organs, which dictate whether the bird will be a more - or less – efficient organism in the future. A good start from the first hour on the rearing farm is the best investment for achieving the smooth development of the pullet later. Early, effective control of growth, smooth development, passing important “check points” at six and 12 weeks and starting the lighting program at optimum age all contribute to the development of a uniform flock that will produce uniform eggs.

Advice:

- Ensure the highest growth rate in the first week of life. High average body weight at seven days – usually related to high uniformity - is an indication that all chicks started well.
 - Avoid needing to correct body weight: start feed restriction by the end of first week and apply small but regular weekly increments of daily rationing.
 - Start grading in the fourth week, to allow sufficient time for directing extreme groups towards the common target at 12 weeks.
 - Aim to keep the flock strictly on target body weight at six and 12 weeks of age.
 - Assure good environmental conditions, regular feed increments, sufficient feeding space and good disease control during the entire rearing period.
 - Start maturity-stimulating programs when the majority of hens are ready. Even a uniform flock will include a proportion of birds that mature earlier or later. Well controlled lighting during rearing and not starting the stimulation program too early are basic requirements.
- Ensure good feed composition, avoid overfeeding and apply water restriction during the production period. These factors help to maintain uniform egg size.

5

Establishing true fertility in hatching eggs

If it comes to discussions on fertility two different definitions are practiced. A true fertile egg contains a well developed germinal disc (blastoderm), which indicates that the oöcyte, or zygote, was fertilized and an embryo developed during egg formation. Secondly, in the practice of the hatchery fertility is often based on candling, whereby all clear eggs are defined as unfertile and by default the rest of the eggs are considered to be fertile. This second definition of fertility is strictly not correct since clear eggs may contain both truly infertile or they may contain (fertile) embryos that died early.

In hatchery practice problems with fertility are usually first recognized during the candling procedure, when the number of clear eggs is higher than expected. To identify the time and the cause of embryonic death, the hatchery manager may perform an analysis of candled eggs. However, if candling is performed at transfer at day 18, as is often the case, it can be difficult to discriminate between true infertile eggs and eggs containing an embryo that has died before the blood ring stage. This is because membranes from dead embryos degenerate while the eggs are still in the incubator.

By candling at days 7 - 10, it is possible to reliably discriminate between true infertility and early embryonic death for two reasons. Firstly, because embryonic membranes formed during the first days of incubation can still be recognized. Secondly, in clear eggs collected between days 7 - 10, a change in the color of yolk as a result of embryonic activity is clearly visible. The active young embryo transports water from albumen to yolk, which results in a whitish or light yellow ring around the embryo.

The fertile, unincubated egg contains an embryo (germinal disc or blastoderm) that developed from the fertilized oöcyte (zygote) during egg formation in the oviduct. The oöcyte is the female gamete that floats on the yolk. When the yolk is released in the oviduct, spermatozoa (male gametes) penetrate the yolk membrane, after which only one spermatozoon fuses with the oöcyte to form the fertile zygote. Finally, during egg formation in the oviduct, the zygote develops into the blastoderm, with a recognizable Area Pellucida (AP) surrounded by an Area Opaca (AO) (figure 1a). If for whatever reason the spermatozoa do not reach the oöcyte, the egg remains infertile and the oöcyte will degenerate to form nothing more than a small germinal disc. The infertile germinal disc is visible as a compact white spot with ruffled edges (figure 1b). If hatching eggs are analyzed on arrival at the hatchery, before incubation, any issues with infertility can be communicated with the breeder farm without delay.

Advice

- Candle eggs at transfer (day 18) as a standard routine.
- If the number of clears is above acceptable or allowable standards, perform egg analysis, to distinguish between infertility and early embryonic death.
- Consider candling followed by egg analysis between day 7 - 10, as a more reliable means of measuring true fertility.
- Analyse a minimum of 10 fresh, un-incubated eggs on a regular basis when issues with fertility are suspected.
- If true infertility is too high, communicate with the breeder farm about male AND female management.

- If the rate of early death before the blood ring stage is too high, evaluate conditions during storage and the transport of eggs - and ensure that the setter is bringing the eggs to incubation temperature rapidly and without interruption.

Figure 1a – Drawing showing the appearance of a fertile germinal disc

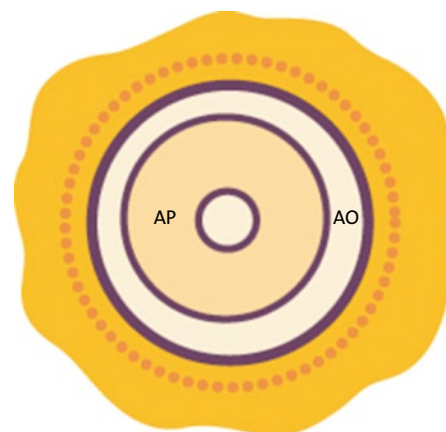
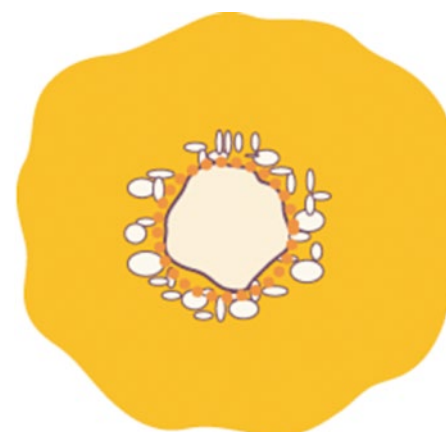


Figure 1b – Drawing showing the appearance of an infertile germinal disc



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6

Managing fertility: good breeding shows



The percentage of fertile eggs is one of the most important parameters influencing the economic performance of a breeder flock. An embryo can of course only develop from a fertile egg.

Fertilization takes place – and thus can only be influenced – on the breeder farm. When we consider fertility, we usually think of the males. Yet in reality, the percentage of fertile eggs is a synthetic expression describing the condition and activity of the males, the condition of the females - and the propensity of both sexes to behave as nature intended. Sexual behaviour is closely allied to the contentment and welfare of the flock. Or put another way, fertility can be seen as a reliable measurement of the flock's overall wellbeing.

A flock performing well in respect to fertility is one where both cockerels and hens are healthy and well developed. Both groups (sexes) should be uniform, with similar levels of maturity and well matched in size, good feathers and healthy, strong legs. These tend to be the characteristics of flocks in a low-stress environment, with sufficient space to promote natural behaviours and an optimum diet.

With these conditions, the inevitable changes related to the advancing age of the birds will proceed synchronically. In this sense, fertility is a trait that can be regarded as a dynamic process, rather than as a single characteristic. From the economic point of view, the deciding factor is the level of fertility that can be delivered in the late production period, after 45 weeks. This is also a time when the most differences between the flocks can be observed.

Advice

To promote enhanced fertility in the flock:

- Give special attention to development and uniformity in rearing: a good start in the first week, harmonic, steady growth, maintaining body weight standards from the beginning of the chick's life and especially at 11 weeks are essential.
 - Synchronize the maturity of males and females. Many potential problems arise from differences in development between the sexes. Males tend to mature earlier and may behave too aggressively for successful breeding.
 - Observe behaviour in the poultry house in the afternoons - and be prepared to respond quickly. A good flock should remain active and well mixed at this time.
 - Restrict water consumption at any age and take care of litter as a key factor in determining the house environment. Dry, loose litter helps the birds to remain clean and well feathered with healthy legs. Maintain feed to water ratio as 1: 1.7 - 1.9 in rearing and 1: 1.8 - 2.2 in the production period. Always ensure that the house is dry and warm.
 - Avoid stress by limiting factors like diseases, drastic changes of housing conditions, feed composition or quantity, temperature and other basic parameters. Stick to routines.
 - Stimulate mating by sprinkling grain on the litter in the afternoons. Let the males play the role of landlords, so they have the chance to show their leading position in the flock.
 - Never keep too many males in the flock. Quantity cannot replace quality. It is better to keep fewer good cockerels than many of varying quality.
- If possible, replace old cockerels with new, mature males after 45 weeks of age. Alternatively, introduce 'intra-spiking': the exchange of males between different houses. This creates a new social order that encourages increased activity and renewed fights for social position. Replace or exchange at least 40 % of the males in a house.

Care of the egg: from nest to farm store

A healthy, well managed breeder flock, receiving a balanced feed ration, will produce good quality hatching eggs. At the moment an egg is laid, it contains an embryo of 30,000 - 60,000 cells. At that point in time, each cell is already programmed for its future function. With the best of care, the hatching potential held in this delicate embryonic structure will be fully realised. But get it wrong – and much can go amiss between nest and farm store.

Although the exact level of the so-called 'physiological zero' is debated by hatchery specialists and researchers, there is a general consensus that embryonic development, which starts in the hen's body, will continue as long as internal egg temperature is more than 25 - 27 °C.

Ideally, eggs should be cooled down uniformly and gradually from body temperature to between 18 and 25 °C in 6 - 8 hours. However the rate of cooling depends on several factors. Nest type in relation to frequency of egg collection plays an important role. Eggs produced in manually collected litter nests cool down very slowly to environmental temperature, due to the insulation provided by the surrounding nest litter. Since nest boxes are shared between 5 - 7 hens, warmth is brought to partially cooled-down eggs again every time another hen enters the nest. It is only once eggs are collected, that they are able to cool down properly. In automatic nests, the eggs roll away to an egg transport belt soon after being laid, which exposes all the eggs to a similar environmental temperature.

Egg temperature at the moment of collection will vary from egg to egg, with some still holding a temperature of more than 25 °C. In this case, further cooling is required. A newly produced egg, with a temperature close to that of the hen's body (41 °C), will take much longer to cool down when placed at the centre of a pulp tray and covered by the next full tray, than an egg placed at the side of the pulp tray. Ensuring that there is an adequate supply of free circulating air over the trayed eggs will greatly assist in providing uniform cooling.

And there are further considerations when seeking to maintain the quality of the eggs after oviposition. For example, too many eggs in a nest leads to an increased incidence of hair cracks, with a negative effect on hatchery results. Hair cracks can also result from over-filling the egg transport belt, which causes the newly laid eggs to bump against each other. Nest hygiene, too, is important for the avoidance of contamination. Floor eggs are a hotbed of infection in the hatchery, affecting both hatchability and chick quality, with further reaching effects also extending to increased first week mortality and reduced performance in the receiving farms.

Advice

- Handle eggs with care at all times.
- Avoid shocks and jolts in handling. Remember that not only is the shell fragile, but also that inside exists an equally fragile embryonic structure!
- Collect eggs from manual litter nests at least 4 times/day.
- Collect eggs from automatic roll away nests 2 - 3 times/day, ensuring that temperature on the egg transport belt is 18 - 22 °C.
- Maintain a temperature of 18 - 22 °C in the egg collection room, to prevent eggs cooling down too quickly or warming up again.
- Maintain good nest hygiene at all times. Close the nests during the night, and ensure that they are opened again before the start of egg production the next morning.
- Avoid floor eggs, which should not be incubated, by good management practice that starts from the rearing period.
- Allow sufficient airflow over the eggs after collection to ensure uniform cooling. This is best achieved by collecting eggs on setter trays. Eggs should never be packed in cardboard boxes before they have cooled down.
- Further avoid hair cracks by using well designed trays, without sharp edges, that adequately support the eggs. Do not use sloppy trays and avoid overstacking.

Hatching egg transport



Breeder farms are often situated away from the hatchery. The distance between the two sites therefore becomes an important consideration when planning the transfer of eggs to the hatchery. Typically, deliveries vary from daily to not less than twice weekly, as increased storage time has a negative impact on hatchability and chick quality.

Egg transport is generally by truck, although when importing hatching eggs, air transport may also be used. When flying eggs, it is worth remembering that delays can occur during transfer from aircraft to truck and while waiting for customs clearance.

Because hatching egg transport is actually a period of transition from the farm store to the hatchery egg store, it is important that climatic conditions are kept optimal, to maintain hatching potential as much as possible. Ideally, temperature inside the truck should be equal to temperature in the farm store.

The cooling down of newly loaded eggs should always be avoided, especially if the vehicle is already loaded with eggs from other farms. When eggs cool, the volume of albumen and yolk shrinks, thus increasing air cell volume, which will allow contaminated air to be sucked into the egg.

Conversely, if the temperature in the truck is higher than in the store, the risk of 'sweating' (condensation forming when the colder surface of the egg is exposed to humid air) increases. Even when store and truck temperatures are equal, sweating can still occur during loading and unloading, especially on warm and humid days. In such a case, a higher on-farm storage temperature of 23 °C instead of the

generally recommended 18 - 20 °C can be considered. Bourassa et al (2003) found that this will produce equally good hatching results, while minimising sweating during loading.

Egg temperature can change rapidly when loading, especially when air velocity is high. This mainly affects eggs on plastic or setter trays, but it is also true for eggs on pulp trays - placed at the side of a buggy. Using buggy bags can delay temperature changes in a situation like this. But avoid direct sunlight on the bags! In a very short time, the temperature under the plastic can rise to 50 °C!

To avoid negative affects on embryo vitality during transportation, sudden temperature changes, shocking and jolting should be avoided at all times.

Advice

- Adjust vehicle temperature to that of the storage rooms of all supplying farms. The hatchery should play a coordinating role.
- Reduce the risk of sweating by reducing relative humidity in the vehicle. Providing transport time is not longer than 12 - 24 hours – the effect on the quality of hatching eggs is negligible.
- Avoid sudden temperature changes during loading and unloading. Connect the truck directly to the storage room whenever possible or consider using buggy bags – especially in situations of high air velocity and low air temperature. Always avoid direct sunshine and watch for unwanted condensation forming under these bags.
- Ensure a constant and uniform climate during egg transport.
- Always avoid unnecessary delays.
- Avoid shocks and jolts during loading and transport – use trucks with good

suspension and trolleys with shock absorbing wheels. Maintain access roads to farms and hatchery in good condition.

- Adequately support eggs in well designed trays without sharp edges. Do not use sloppy trays and avoid overstacking.
- Always transport eggs small end down, to avoid loose air cells.
- Use temperature loggers during transport to record any temperature fluctuations.
- Take internal egg temperatures at different locations within each batch received at the hatchery, to check temperature conditions during transport.
- After transportation, rest the eggs for at least 12 hours before starting incubation. Immediate setting will increase early embryonic mortality.
- Clean and disinfect all transport equipment prior to any egg transport, to avoid pathogenic spread.



9

Impact of hairline-cracked eggs on hatchability and chick performance



In general, good quality eggs are selected and placed for incubation. This means that only clean eggs with shell intact should be placed on the setter trays. Dirty or floor eggs and eggs with visible cracks are removed and not placed. Eggs with hairline cracks might often not be recognised and will, consequently, be placed in the setter trays and incubated.

In cracked eggs, the shell is broken and the underlying membrane is ruptured – leading to dehydration and the death of the embryo. However eggs with undamaged membranes but broken shells are defined as having hairline cracks – and these are often placed because unless candled, they look like good quality eggs.

A study of the incubation of good quality hatching eggs versus those with hairline cracks produced the results shown in the summary. In this experiment, eggs from five commercial flocks of various strains were candled and an equal number of hairline-cracked and normal eggs were incubated for 21 days. Eggs were identified as having a hairline crack if the crack was visible by candling, but not apparent when examined normally.

	Good quality eggs	Hairline-cracked eggs	
Hatchability (%)			
– Eggs set	74.4	50.5	Significant (P < 0.05)
– Fertile eggs	80.9	56.4	Significant (P < 0.05)
Chick weight			
– Weight (g)	45.0	43.5	Significant (P < 0.05)
– Relative weight (% of eggs set)	69.9	67.5	Significant (P < 0.05)
Growth performance			
– D14 body weight	293.5	298.9	Not significant
– Mortality	2	7.5	Significant (P < 0.05)
Egg weight loss in the setter (%)	13.4	17.02	Significant (P < 0.05)
Embryonic mortality (%)			
– Early (1 - 7d)	7.9	13.9	Not significant
– Mid (8 - 14d)	0.0	2.9	Significant (P < 0.05)
– Late (15 - 21d)	4.6	15.5	Significant (P < 0.05)
– Cull	5.3	6.2	Not significant
Contaminated or broken (%)	1.2	5.2	Significant (P < 0.05)

Reference: Barnett et al. (2004). Hatchability and Early Chick Growth: potential of broiler breeder eggs with hairline cracks. J. Appl. Poult Res. 13: 65 - 70.

The study concludes:

- 1 Setting eggs with hairline-cracks significantly reduces hatchability.
- 2 Chicks hatched from hairline-cracked eggs demonstrate higher mortality during a 14 day growing period.
- 3 Egg weight loss during the setting period increases significantly in hairline-cracked eggs, producing smaller chicks as a consequence. This however has no effect on day 14 weight.
- 4 Compared to good quality eggs, a significantly higher incidence of contaminated and broken eggs was found after incubating eggs with hairline-cracks.

Advice

- Do not set hairline-cracked eggs.
- Candle egg samples from batches transported to the hatchery on a regular basis to evaluate the incidence of hairline-cracked eggs.
- Record the number of eggs with hairline-cracks.
- If the frequency of hairline-cracked eggs is unsatisfactory, investigate and eliminate possible causes.
- Avoid the use of plastic trays with sharp edges for the transportation of eggs, as these are likely to be a major cause of hairline-cracks.

10

Pre-storage incubation: a matter of routine?



The care of hatching eggs during storage – at the farm, in transit or at the hatchery – is an important aspect of hatchery management that aims to preserve the vitality of the embryo.

With optimum temperature and relative humidity, hatching eggs can generally be stored for one week without significantly reducing hatchability or chick quality. Eggs stored for longer than this are known to benefit from lower storage temperatures (12-14 °C) (Fasenko, 2007; personal experience).

Pre-storage incubation, i.e. incubating hatching eggs before they are placed in the storage room, is a new approach to storage management that aims to develop the embryo to the so-called hypoblast stage: a stage of embryonic development that is better able to survive storage.

According to Fasenko (2007), broiler hatching eggs reach the hypoblast stage after six hours of pre-storage incubation, turkey embryos after 12 hours. Layer hen hatcheries have reported improved performance, seeing 3-7 % more females after pre-storage incubation for 3-6 hours, when eggs are stored for more than 11 days (Lohmann Tierzucht, Management Guide).

In the broiler industry, positive pre-storage incubation results show at least a one per cent increase on expected hatchability, when the eggs undergo pre-storage incubation of 3-6 hours on arrival at the hatchery (Fasenko et al., 2001; Fasenko, 2007).

Eggs scheduled for storage for more than seven days after production benefit most from pre-storage incubation. However, many questions, mainly concerning timing and duration, continue to surround the adoption of pre-storage incubation in routine management practice.

Considerations for the practice of pre-storage incubation

Pre-storage incubation is only beneficial if the embryos in the eggs are in a very early stage of development. For example: if nest temperatures are high and the eggs stay in the nest too long, the embryos may develop beyond the storage resistant stage, when pre-storage incubation will increase early embryonic mortality. Small-scale experiments will help identify the best timing and length of pre-storage incubation for your own hatchery and egg types (see below). To assess results in your own hatchery:

- Place eggs for pre-storage incubation on setter trays in setter trolleys, to ensure uniform egg temperature during incubation.
- Do not incubate eggs on paper trays or in boxes. This guarantees heterogeneous egg/embryo temperatures, resulting in high levels of early mortality.
- Disinfect eggs as long as pre-storage incubation is performed in a setter located in the setter room ('clean area'). Ideally use a specific incubator, located close to the egg storage room.
- Pre-storage incubation can be applied when eggs arrive at the hatchery 3-4 days after production and are scheduled for more than 4 days extra storage at the hatchery.

Guidelines

To assess performance benefits and establish pre-storage incubation protocols in the hatchery:

1. **Egg selection:** per egg type, three trolleys for pre-storage incubation with one trolley (same batch) for the control.
2. **Disinfect:** if the eggs are incubated in a normal routine setter.
3. **Pre-storage incubation:** place trolley(s) with (disinfected) eggs in a running setter at incubation temperature. Incubate the eggs for 3, 6 and 9 hours. Control eggs stay at storage temperature.
4. **Return** pre-storage incubated eggs to the storage room (with control eggs) for at least seven days before starting the normal incubation cycle.
5. **Run normal incubation** with both the pre-storage incubated eggs and the control eggs.
6. **Evaluate:** compare hatchability - pre-storage incubated eggs vs. control eggs.
7. **Repeat** this experiment with eggs from at least three different flocks.
8. **Evaluate** all results. If positive, adopt pre-storage incubation routine as indicated by results.

Storage of hatching eggs



Egg storage is the time between oviposition (laying) and the start of the incubation process for hatching eggs. Optimal hatching results and chick quality can be achieved if eggs are set after an initial adaptation period of about 1 to 2 day(s). This allows carbon dioxide to be released from the egg, which increases albumen pH from 7.6 at oviposition to pH8.8 – 9.3. Yolk pH remains virtually constant around pH6.5, so that the embryo, situated on the yolk, is exposed to a pH-gradient. This optimises early embryonic development.

Storing eggs beyond two days leads to loss of hatchability and reduced chick quality. An epidemiological study of Dutch hatchery data (Yassin et al. 2008) showed that, on average, each extra day of storage at the hatchery before the seventh day reduced hatchability by 0.2 %, rising to 0.5 % after the seventh day.

Day-old-chicks from stored eggs show a higher incidence of 'black navels'. Tona et al. (2004) found that Cobb broiler chicks hatched from eggs stored for seven days weighed over 200 grams less at slaughter age, than chicks from fresh eggs. Differences in body weights emerged at 14 days post hatch and increased until slaughter age at 42 days.

In recent research by Pas Reform Academy, eggs from three different broiler breeder flocks of different maternal ages (30, 38 and 50 weeks) were stored at 18 - 20 °C and 12 - 14 °C for 7 and 11 days, both at 75 % relative humidity. Storage at the lower temperature resulted in a higher average hatchability of 0.6 % (experiment 1: 7 days), 1.1 % (experiment 2: 7 days) and 3.2 % (experiment 3: 11 days). These results support the view that 'the longer the storage period, the lower the storage

temperature', but more research is needed before it can be concluded that suggested temperature ranges should change.

Advice

- Allow eggs to cool gradually, from the hen's body temperature to between 18 - 25 °C in 6 - 8 hours; do not place them in storage (especially not if already placed on setter trays) too quickly after lay.
- Minimize the duration of storage to counter negative effects.
- Be aware that storage starts on the day of egg production, not necessarily the same as the date of receipt at the hatchery.
- Label each batch of eggs with its actual date of production.
- Maintain optimal climatic conditions during storage (see table), taking the planned duration of storage into consideration.
- Consider having two separate storage rooms, each with specific climate conditions, if storage time is not constant.
- Store eggs small end up, starting on the first day of storage, if hatchery planning dictates that eggs must be stored more than 10 days. Alternatively, if eggs are stored on setter trays (blunt ends up), turn them 90° once daily.
- Choose the upper limit of recommended temperature ranges if there is a risk of 'sweating' when eggs are removed from storage. Gradual warming in a 'pre-processing room' at an intermediate temperature may be necessary.
- Position eggs in storage to avoid direct air flow from egg room coolers and/or humidifiers - and sufficiently removed from the heating system.
- Do not place eggs directly against the wall or on the floor in the storage room.

- Allow extra incubation time for stored eggs: on average one hour extra for each additional day after an initial storage period of three days.

Storage duration	Temperature (°C)	Relative humidity (%)
0 - 3 days	18 - 21	75
4 - 7 days	15 - 17	75
8 - 10 days	10 - 12	80 - 88
More than 10 days	10 - 12	80 - 88

12

The importance of preventing 'sweating' eggs



'Sweating' of eggs refers to the phenomenon of condensed water sitting on the egg shell surface. This occurs when cold eggs are suddenly exposed to a higher environmental temperature. The warm air with a certain moisture content cools down rapidly directly around the colder eggs. Since cold air contains less water than warm air, relative humidity will increase until the air is saturated. And at that moment, condensation will take place on the cool egg surface.

The term 'sweating' is, if taken literally, misleading, because the water on the shell does not in fact come from within the egg. The same physical process is seen when a bottle of water is removed from a refrigerator on a warm summer day.

Sweating of eggs should be avoided because moisture on the shell surface weakens the egg's natural defence mechanisms, providing as it does an ideal environment for the growth of micro-organisms, and further facilitating their penetration through the shell pores.

Once inside the pores, micro-organisms are protected from most routine egg sanitising operations, therefore presenting a potential risk for contamination. Bacteria and fungi which manage to pass through the shell membranes will multiply at a rapid rate when they are exposed to incubation temperature, because the defence mechanism in the albumen is no longer able to protect the growing embryo.

This of course will lead to increased embryonic mortality, 'exploders' and infected day-old-chicks (increased first week mortality).

Clearly moisture on egg shells should be prevented. Egg sweating is prevented when the difference in temperature between the egg storage room and 'the outside' (e.g. loading platform of the truck, egg traying room, setter) is small and the 'outside' humidity is low.

The table below can be used to predict whether sweating will occur if no additional measures are taken. For a wider range of temperatures and humidities, a so-called 'Mollier' diagram or psychometric graph provides a useful tool.

There is also a risk of eggs sweating if they are set too cold in setter that is already running to temperature, as is the case in multi-stage incubation practice.

Advice

- If the risk of sweating is high, pre-warm eggs gradually at least six hours prior to removing them from the egg storage room. This is achieved by switching off the egg room cooler several hours before taking out the eggs. It is important to realize that not all eggs warm up at the same, uniform speed, especially with low air circulation and if stored on pulp trays and stacked closely together.
- Store at a higher temperature, combined with a shorter storage period.
- Connect the truck picking up the hatching eggs *directly* with the storage room to minimise any temperature differences from the outside environment.
- Ensure that the climate in the truck is the same as in the egg store.
- Maintain humidity below the levels indicated in the table.
- Prior to placement in the setter, place the filled setter trolleys at a room temperature of 25 °C with good air circulation for several hours. This pre-warming of the eggs before setting is particularly important when using multi-stage incubation.

Eggs will 'sweat' if the relative humidity (% RH) outside the storage room is higher than:

Temperature of storage room ¹	Temperature outside the storage room			
	15 °C	18 °C	21 °C	24 °C
21 °C	> 85 % RH
18 °C	> 83 % RH	> 71 % RH
16 °C	...	> 89 % RH	> 74 % RH	> 60 % RH
11 °C	> 74 % RH	> 64 % RH	> 53 % RH	> 44 % RH

¹ Assuming that the temperature of the eggs equals the temperature of the egg storage room.

13

Formalin-free hatching egg disinfection: an achievable goal!



Disinfecting hatching eggs is a critical control point (CCP) in the poultry production chain, aimed at reducing the introduction of pathogens into the hatchery for the production of healthy day-old-chicks.

Properly carried out, fumigation with formaldehyde gives excellent disinfection results at relatively low cost – and has become a common method of disinfecting hatching eggs worldwide (see Cadirci (2009) for a detailed review).

However, contra-indications for human health and the environment have already prompted several countries to ban the use of formaldehyde and, as pressure grows to discontinue its use, more are expected to follow.

However, there are several good alternatives, both for disinfectants and in methods of application. Applying disinfectant as a gas, as with fumigation, is advantageous because many eggs can be disinfected simultaneously, with the added assurance that the entire surface of each egg is properly treated.

The same quality of disinfection can be achieved by Low Volume Misting, which produces a very fine fog with a maximum droplet size of 10 microns. Hatcheries employing this method report good results with air supported nozzles, while noting that to achieve even distribution of the disinfectant over eggs that are tightly packed on setter trays loaded in setter trolleys, some fine-tuning of air pressure and the supply-pressure and –speed of the disinfectant solution is required. Trials are currently underway to find a more robust, less sensitive type of nozzle.

Depending on the type of disinfectant used, between five and ten litres of disinfectant, in solution according to the manufacturers' instructions, is sufficient to disinfect 115,200 eggs loaded on 24 setter trolleys. Complete disinfection can be achieved in less than one hour, depending on the number of nozzles used, with the further benefit that existing (formalin) fumigation rooms can be adapted to deliver Low Volume Misting without major renovation.

With Low Volume Misting, the egg surface becomes slightly wet, which is a good indication that the disinfectant is properly distributed. While it is true that eggs should not get wet by water eg. rain, humidifiers or condensation, which provides a transport medium for bacteria to enter the egg through pores in the shell, it is a myth that eggs should not get wet when using a suitable disinfectant, which will kill micro-organisms and presents no threat.

Disinfectants containing quaternary ammonium compounds combined with glutaraldehyde and hydrogen peroxide in combination with peracetic acid have been used successfully for hatching egg disinfection. Overdosing should be avoided, as this may either cover the pores, which could hamper weight loss and gas exchange during incubation, or damage the protective cuticle.

A further and more recent development is the sustainable, onsite production of a highly effective, non-toxic disinfectant that is known to have no adverse side effects with continued use. Electrical Chemical Activation (ECA) of a saturated sodium chloride solution, found its origins in the Soviet Space Program several years ago. It has been further developed by Dutch company Watter BV, such that it now delivers a disinfectant solution in a reliable and repeatable manner.

This disinfectant, which contains active chlorine compounds, different hydroxyls, hydroxyl radicals and oxygen compounds, has been extensively trialed by several Dutch hatcheries, who report excellent results, with the additional benefits of user, material and environmental friendliness. Production costs are extremely low.

Whichever route the hatchery chooses, it is clear that formalin-free hatching egg disinfection is achievable in the hatchery.

Advice

- Disinfect shell-clean hatching eggs only.
- Ensure good distribution of the disinfectant over the entire surface of every egg.
- Evaluate the type of disinfectant, dilution rate and quantity not only by reduced numbers of micro-organisms, but also by effects on weight loss during incubation and the effect on cuticula, hatchability and chick quality.
- Consider the effects of the disinfectant on personnel, equipment and your environment over the long-term.

14

The effects of setting eggs small end up on hatchability and chick performance

Eggs are incubated in setter trays for most of the incubation period. Three days before hatch, the eggs are transferred to hatcher baskets. In the setter trays the eggs are placed vertically with the air cell (large end) up, while the eggs lie horizontally during hatching.

In normal development, the embryo begins to turn to its position along the long axis of the egg at day 14. At day 18, the beak is turned to the air cell and covered by the right wing. In this position the embryo can penetrate the inner cell membrane to gain access to the air in the air cell – after which breathing starts.

This normal sequence of events is disturbed when the eggs are placed with the air cell down and the small end up. In this scenario, the embryo still turns along the long axis of the egg with the head up – but now, the head is positioned in the small end of the egg – away from the air cell. The embryo may die because the initiation of normal lung breathing is hampered or even blocked.

Hatchability of eggs placed with small end up decreases from 12 - 30 per cent when compared to hatchability in eggs set large end up. However, once hatched from an egg set small end up, the performance of chicks is no different to that of chicks hatched from eggs placed large end up. The table on this page shows a summary of data collected from commercial hatcheries. Over 3,600 eggs were candled from each flock. The percentage of eggs placed small end up varied between 0.29 - 3.4 per cent, irrespective of the shape of the eggs.

Flock		Large end up	Small end up
A	Hatchability (%)	97.6	79.5
	Cull (%)	0.0	3.6
	Grade-A chicks (%)	97.6	75.9
B	Hatchability (%)	96.9	71.8
	Cull (%)	3.0	4.3
	Grade-A chicks (%)	93.9	67.5
C	Hatchability (%)	100.0	84.0
	Cull (%)	2.0	4.0
	Grade-A chicks (%)	98.0	80.0

Reference: Bauer F, Tullet SG and Wilson HR (1990). Effects of setting eggs small end up on hatchability and posthatching performance of broilers.

The incidence of eggs set upside-down is largely dictated by human error and not by the shape of the eggs. Great variation between trays in the number of eggs placed upside down was observed: some trays had none, while others had 10 - 12 eggs placed small end up. Hatchability of eggs set small end up decreased by 16 - 27.3 per cent. The percentage of non-viable chicks from eggs set small end up increases, but varies between different batches of eggs. A hatchery loses 0.2 per cent of sellable chicks for each 1 per cent of fertile eggs placed with the small end up in a setter tray (Bauer et al, 1990).

Advice

- Check each batch of eggs for the incidence of eggs placed small end up (upside down).
- Record the number of eggs placed upside down.
- If the frequency of eggs placed upside down is unsatisfactory - investigate and remedy the reasons for misplacement of the eggs.
- If the eggs are routinely set in setter trays at the breeding farm, communicate the benefits (profit) of good placement and place responsibility for ensuring that eggs are placed correctly with farm personnel. Breeder farm personnel should all be aware of the fact that the hatchery loses 0.2 per cent of sellable chicks for every 1 per cent of fertile eggs placed small end up in a setter tray.

The benefits of single-stage incubation to food safety

Typically, papers on single-stage incubation focus on the benefits of all-in-all-out incubator management from the points of hatchability (number of chicks) and uniformity (chick quality). Much less is written about the positive impact of single-stage incubation management on hatchery hygiene. Yet when food safety is such a pivotal issue for the modern hatchery, from tracking and tracing to physical hygiene and biosecurity measures, this is a major benefit that should not be overlooked.

Background

Hastings' invention of the forced-draught incubator in 1911 was a great step forward in the technology of large scale incubators. Cooling in these early, forced-draught machines was mainly based on air cooling to prevent the eggs from overheating, and very little on water cooling. The air temperature was controlled at a fixed set point, by balancing the heat produced by older stage embryos with the heat-absorption demands of the younger embryos: so-called *multi-stage* incubation.

That innovation has been with us for almost 100 years. And despite an explosion in the physical scale of commercial hatcheries, and massive advancements in climate control technology - simplicity of incubator management, slow replacement rates for hatchery equipment and low labour costs in many countries mean that multi-stage incubation is still favoured by many hatcheries today.

Management

The simplicity of multi-stage management stems from the fact that new, unincubated eggs are placed alternately with eggs containing older, heat producing embryos.

New eggs are placed regularly, once or twice a week. In the multi-stage system, the climate is controlled by the eggs.

Conversely, single-stage incubation is based on climate control technology, geared specifically to meeting the demands of the growing embryo. The incubator climate controller provides the embryo with heat and cooling as required. Set points of temperature, relative humidity and ventilation are adjusted, according to embryonic age. Eggs are placed in empty, disinfected incubators.

Single-stage hatchery management may also be based on the daily routine. Single-stage incubation programmes, once set-up for different eggs types, can be applied routinely.

Hygiene and food safety

The climate in a multi-stage incubator is controlled by levels of heat production in 'older' eggs, which heats the freshly placed eggs by air transfer. However, 'older' eggs are not only a source of heat. They are also a source of micro-organisms, for example bacteria or fungi, which can contaminate the 'younger' eggs. Add to this the risk of exploding or gaseous eggs, and contamination early in life may have lasting implications, leading to contaminated broilers with decreased performance, higher mortality - and ultimately contaminated meat products.

Thus, from a hygiene and food safety point of view, the multi-stage incubator becomes a source of contamination, which may lead to economic losses at hatchery level due to lower hatching rates and chick mortality.

The whole production chain is controlled by strict legislation for chain management (tracking and tracing) and hygiene. The integration of a single-stage hatchery in such poultry production systems is a simple task, because the principle of all-in-all-out makes the tracking and tracing of different batches of eggs easy.

To fill the multi-stage incubator, a batch of eggs from one supplier must often be separated into smaller batches and placed in different setters. This complicates tracking and tracing, making errors more likely to arise.

And the multi-stage incubator is never completely empty - making thorough disinfection almost impossible. Single-stage incubation, however, allows for the machines to be thoroughly cleaned and disinfected every 18 days (between batches of eggs).

Advice

To enhance food safety at hatchery level in the production chain, the single-stage incubation process delivers benefits not available through multi-stage incubation by:

- Preventing cross-contamination from older to younger egg batches, because eggs of different ages need not be mixed.
- Facilitating the simple identification, tracking and tracing of each hatch.
- Enabling thorough cleaning and disinfection between hatch cycles.

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How hatchery management changes when starting single-stage incubation



Management in a multi-stage hatchery is based on a daily routine of setting eggs according to a strict setting schedule per setter type. The common principle for establishing a setting schedule in a multi-stage incubator is based on the need to transfer metabolic heat from more developed embryos to the less developed, heat-demanding embryos in the early stage of embryonic development.

Embryo temperature in a multi-stage incubator is mainly controlled by the pattern of alternating 'old' heat producing embryos and 'young' heat demanding embryos. The incubators are filled according to the direction of the airflow in that specific make or model of incubator. In addition the temperature controller is fixed at a specific set point. Embryo temperature is thus only supported approximately in multi-stage incubators.

Management in the multi-stage hatchery cannot accommodate egg quality or the needs of the growing embryo. However, it has becoming increasingly clear that today's modern breeds need a more accurate approach to incubation to achieve high numbers of good quality chicks that fully realise their genetic potential (Fairchild et al, 2007). Furthermore, the multi-stage incubator cannot easily be cleaned - because it is never empty.

For these reasons, more and more hatcheries are making the transition from multi-stage to single-stage incubation management.

Single-stage incubation runs specific incubation programs such that the climate in the incubator is programmed to match the specific needs of the developing embryos. Single-stage

incubators can also be cleaned after each incubation cycle and thus meet high hygienic standards of today's food production industry.

Often, the transition from multi-stage to single-stage incubation is initiated by the replacement of aged multi-stage incubators by new single-stage equipment, without an awareness that hatchery management too will need to be adjusted. Management in a single-stage hatchery is certainly not based on a routine, but rather adjusted to accommodate the needs of a specific egg type. Consequently, hatchery managers need to learn about variation in needs of embryos from different egg types, as defined by strain, flock age and the duration of storage.

Advice

- Plan size of setters in accordance with size of batches of eggs. A batch of eggs is the total number of eggs produced on a specific day by one flock in one farm.
- Create an overview of the egg types incubated in your hatchery.
- Do not mix different batches of egg types. If separating egg types for incubation is not possible:
 - Fill setters with batches of eggs that have similar characteristics with respect to strain, flock age and days of storage.
 - Avoid filling one incubator with eggs from flocks more than 5 weeks apart in flock age.
 - Avoid filling one incubator with eggs from one flock but with more than 5 days' storage difference.
 - If the incubator has to be filled with more than one batch of eggs, do not combine fresh eggs with eggs stored for more than 5 days.
- Follow manufacturer's guidelines carefully when starting the first incubation cycle in the single-stage incubator.
- Keep records for each incubation cycle, per egg type used and showing the different management steps taken per type.
- Use data with respect to hatchability, incubation time and chick quality from recording forms to fine-tune your incubation programs.
- Train hatchery personnel so that they are fully advised regarding the different management steps required when using single-stage practices.
- Highlight the need for change: make sure hatchery personnel understand that single-stage management requires a different approach to multi-stage management to succeed.

Pre-heating – an effective tool for chick uniformity

Modern poultry management for meat production aims to deliver uniform birds to the slaughterhouse. Hatchery practice plays an important role, because success at farm level is greatly enhanced by the receipt of chicks with uniform growth potential.

The hatchery manager using modular single-stage incubators with a pre-heating function has a distinct advantage, because he or she has the necessary tools to effect a uniform start for every embryo in the incubation cycle.

Preheating brings the eggs to a uniform temperature of 25 °C (77 °F) in an operating setter, prior to the onset of incubation. This is the first step towards achieving a short hatch window – and therefore a uniform hatch. In the absence of a pre-heat function on the incubator, eggs can be pre-warmed by placing filled setter trolleys in the setter room.

The hatchery's key aim should be to provide an even, uniform start for all embryos placed in incubation. Preheating makes such a difference, because it minimises variations in embryo temperature at the moment when *air* temperature inside the incubator reaches 38.0 °C (100.4 °F) set point. Variations in egg temperature will be further reduced when eggs are sorted by weight and when incubators with higher heating capacity are used to ensure a uniform start of embryonic development for all the eggs placed inside.

Eggs from different batches are often set in the same incubator, either because the eggs have originated from different farms, or because eggs from different production days have been stored until there are sufficient to completely fill the setter.

Between batches, egg temperatures can differ – especially when, for example, setting is planned for the date of delivery for some, mixed with others taken and set directly from the hatchery cold store.

Variation in egg temperature will also occur as a result of taking eggs from the storage room at different times for loading into the setter. The table below, illustrates that without the benefit of preheating, variation in eggshell temperature is greater after several hours of heating at incubation set point, especially when using an incubator with a lower heating capacity.

Preheating starts off low level cellular processes in some of the embryonic cells. These processes should not be interrupted or halted in any way once they have begun and preheating must be followed immediately by incubation at a setpoint of 38.0 °C (100.4 °F) to achieve optimum embryonic temperature of 37.8 °C (100 °F).

Range in egg temperatures after heating with or without preheating in incubators with two different heating capacities. Egg weight varies between 50 - 70 grams.

Range of egg temperatures before setting	10 hours heating with 2500 W heating capacity		7 hours heating with 4000 W heating capacity	
	No preheating	Including 5 hours preheating	No preheating	Including 3 hours preheating
14 - 20 °C	33.2 - 37.8 °C	34.6 - 37.8 °C	35.5 - 37.8 °C	37.3 - 37.8 °C
57.2 - 68 °F	91.8 - 100 °F	94.3 - 100 °F	95.9 - 100 °F	99.1 - 100 °F

Advice

Preheating eggs prior to incubation is an advantage when seeking optimum chick uniformity. For this reason, modular, single-stage incubation and high heating capacity are also recommended.

For incubators *with* a pre-heating programme

Use the pre-heating programme for the most uniform start to embryonic development.

Starting the incubation cycle after internal egg temperature has reached 25 °C/77 °F (5 - 6 hours after preheat begins) reduces the risk of early mortality.

For incubators *without* a pre-heating programme

Pre-warm eggs to 25 °C in the setter room for a minimum of 12 hours. Trolleys loaded with eggs should be separated to ensure warm air circulates properly to all eggs.

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Finding optimum incubation temperature

When a hatchery manager talks about incubation temperature, he or she refers to the temperature set point at the controller of the incubator. This temperature set point regulates the temperature of the air stream along the incubator's temperature sensors. If the air temperature is too high or too low, the incubator controller adjusts the cooling or heating rates respectively, until temperature set point is reached.

Thus, incubation temperature is dictated by the air temperature surrounding the sensor. However, the hatchery manager knows that there is a critical relationship between incubation temperature, hatchability and chick quality.

Optimum egg shell temperatures

The key parameter for achieving optimum embryonic development is embryonic temperature, represented by the temperature of the egg shell.

From recent research, we know that shell temperature should ideally follow a natural pattern (see figure). During the first 12 days of incubation, optimum shell temperature is $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$), followed thereafter by a gradual increase to $38.4 - 38.6 \pm 0.2^\circ\text{C}$ ($101.1 - 101.5 \pm 0.4^\circ\text{F}$) at day of transfer. From practical experience, we also know that during the first 12 days of incubation, optimum shell temperature varies little between embryos from different poultry strains. Towards the end of the incubation period, however, there are significant variations in the optimum maximum shell temperature for different strains: normal maximum shell temperature for the classic breeds are too high for embryos from modern high yield breeds, resulting in poor quality chicks with poor navels and red dots on the beak.

Optimum incubation temperatures

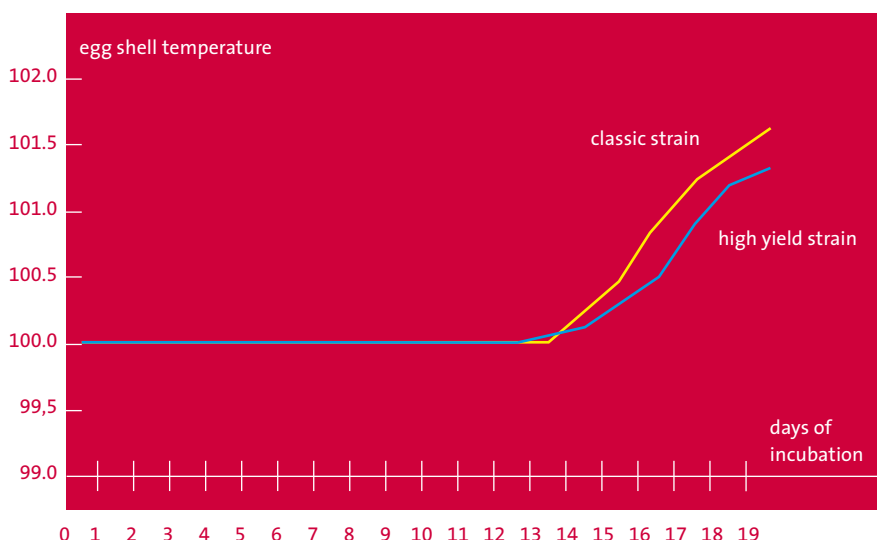
Egg shell temperature is determined by a combination of the metabolic heat produced by the embryos and the climate (temperature, air flow, humidity) surrounding the eggs. In the early phase of embryonic development, very little metabolic heat is produced and the air surrounding the eggs should be heated to keep egg shell temperature at optimum levels. But towards the end of incubation, the production of metabolic heat increases – and this heat must be removed by cooled air flowing over the eggs to avoid the risk of overheating the developing embryos.

Advice

- Define optimum incubation temperatures by measuring the egg shell temperatures of a representative sample of eggs, randomly chosen from different trays in the incubator.
- Do not copy guidelines for optimum incubation temperatures from one brand of incubators to another. Airflow patterns differ between different incubator designs.

- Limit the number of trolleys in front of the fan or air pump to a maximum of two. This guarantees a uniform airflow and even temperature distribution over the eggs.
- Use chick quality as a reference, especially if egg shell temperatures cannot be measured at a regular base.
- Perform a detailed analysis of chick quality (Pasgar@score) to avoid accidental conclusions on overheating. If $\leq 50\%$ of chicks have a fully closed, normal navel and 10% of chicks have a red dot on the beak, reduce the incubation temperature.
- Increase incubation temperatures if day old chick quality indicates an incubation temperature that is too low. This applies if $\leq 50\%$ of chicks have a fully closed normal navel and 20% have a thick belly (large yolk sac), upon detailed analysis of chick quality (Pasgar@score).

Natural pattern of egg shell temperatures for optimum hatchabilities and chick qualities



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Managing incubation temperature to combat increased early mortality



As a breeder flock ages, the number of 'clear' (infertile) eggs increases as a result of decreased fertility and increased early mortality. Consequently, with higher numbers of clear eggs, a higher proportion of the heat produced by developing embryos in the fertile eggs is absorbed by the 'cold' clear eggs placed around them.

Embryonic temperature in the fertile eggs is reduced by a combination of the air flowing over them, together with the 'redundant' loss of heat absorbed by the clear eggs. To achieve optimum embryonic temperature in this scenario, we can compensate for the heat 'lost' to cold, clear eggs by increasing the temperature of the warm air flowing over the eggs.

The temperature of the air flowing over the eggs is governed by the incubator's temperature set point. If air temperature is either too high or too low, the incubator controller adjusts cooling or heating rates respectively, until temperature set point is reached.

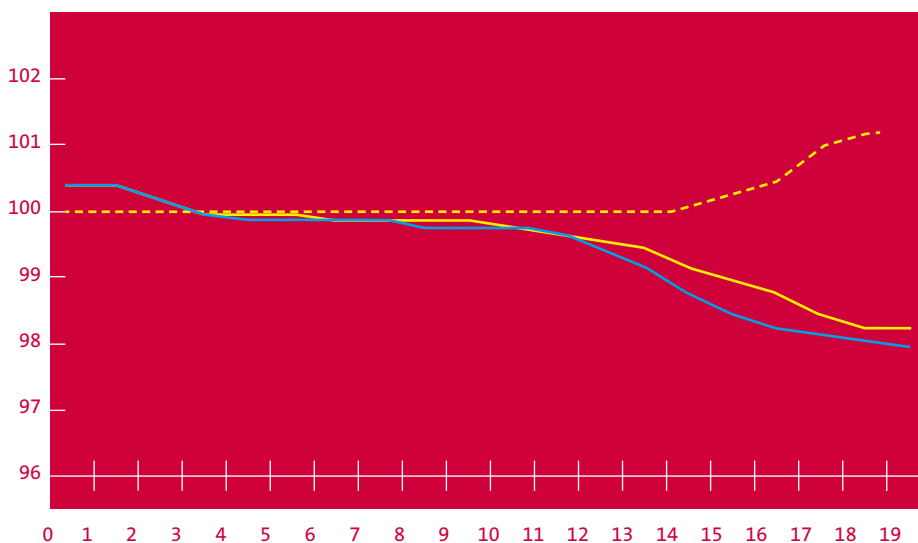
When there are more than an average number of clear cold eggs positioned between developing fertile eggs, incubation temperature should be raised accordingly - in line with rates of fertility and early mortality in each particular batch of eggs. Estimates for these rates per different flock ages should be available in the hatchery's reference data, or in the breeder's management manual.

The hatchery manager knows that there is a critical relationship between embryonic temperature, hatchability and chick quality. Incubation temperatures that are set too low will result in increased mortality and a higher number of hatched chicks with a full belly.

Advice

- Routinely record, per batch of eggs, the percentage of clears, the hatchability of eggs set and hatchability in transferred eggs.
- Estimate the expected percentage of clears per batch of eggs. Adjust set points accordingly if this is < 75 % (more than 37 clear eggs/tray).
- Identify the natural patterns of egg shell temperatures throughout incubation. During the first 12 days, optimum shell temperature is $37.8 \pm 0.1^{\circ}\text{C}$ ($100 \pm 0.2^{\circ}\text{F}$), followed thereafter by a gradual increase to $38.4 - 38.6 \pm 0.2^{\circ}\text{C}$ ($101.1 - 101.5 \pm 0.4^{\circ}\text{F}$) at day of transfer.
- Define optimum incubation temperatures by measuring the egg shell temperatures of a representative sample of eggs, randomly chosen from different trays in the incubator.
- Analyse random egg samples and use chick quality as a reference, especially if egg shell temperatures cannot be measured regularly.
- Consider increasing incubation temperatures if the air cell of dead-in-shell chicks is too small, but first, ensure that this is not caused by relative humidity being too high in the incubator.
- Increase incubation temperatures if day old chick quality indicates too low an incubation temperature. This applies if $\leq 50\%$ of chicks have a fully closed normal navel and 20 % have a thick belly (large yolk sac), upon detailed analysis of chick quality (Pasgar@score).
- Perform a detailed analysis of chick quality (Pasgar@score), to avoid reaching accidental conclusions when incubation temperatures are too low.

Optimum incubation temperatures for a batch of eggs with 65 - 75 % fertility (yellow line) and 85 - 95 % fertility (blue line) to achieve optimum egg shell temperatures (yellow dotted line)



Optimal weight loss profiling during incubation

Good hatchability is dependent on meeting all crucial incubation parameters. One of these important parameters is weight loss. Eggs should lose 11-13 per cent of initial weight during the first 18 days of incubation.

Weight loss in hatching eggs is caused by the continuous evaporation of water from the eggs - and inseparably linked to achieving optimum embryonic development during incubation.

Continuous weight loss from the egg is essential for the formation of the air cell and at the same time, the evaporation of water from the egg facilitates optimised water and mineral balances in the different embryonic compartments formed during embryonic development. As soon as internal egg temperature increases, evaporation through the shell and the transport of water from albumen to sub-embryonic cavity both increase. The transport of water to the sub-embryonic cavity can be observed as a circular change in the colour of the yolk (figure 1b). At day six, most of the water from the albumen has been redistributed, leaving a small jelly-like clod of albumen proteins (figure 1c). As embryonic development continues, the transport and redistribution of water also continues, such that at days 10-12 of incubation, the different embryonic compartments – including the yolk sac, amniotic cavity (figure 1d) and the allantois - are filled with a watery solution containing a balanced concentration of essential minerals. A balanced composition of the embryonic compartments is essential for the transport of nutrients to and waste products from the embryo.

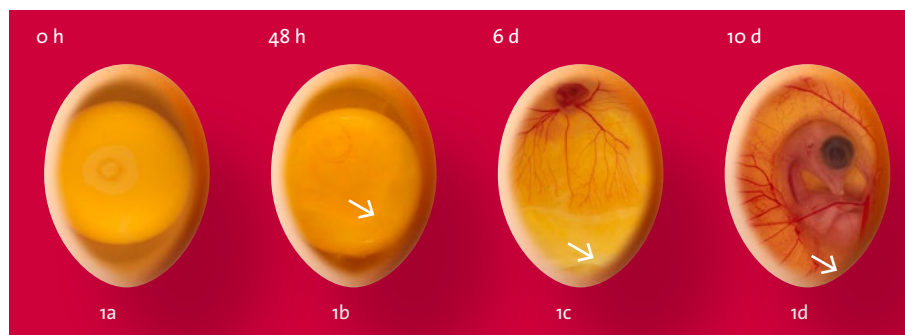


Figure 1. A) Uniform colored yolk in a fresh egg. B) The light colored yolk (arrow). C) albumen is reduced to a jelly like clod (arrow). D) embryo protected by the amnion (arrow).

The redistribution of albumen water over the different embryonic compartments has no effect on absolute weight loss, but it does affect the pattern of evaporation within the egg and therefore has an important effect on mineral balance in the different embryonic compartments. This is best illustrated during the first days of embryonic development, by the loss of egg weight as a result of evaporation from the albumen. In the second week of development however, water evaporates mainly from the allantoic cavity, directly under the egg shell.

If during the first week the valves of the incubator are kept closed and as a result relative humidity levels increase to 75 per cent or more, weight loss is restricted. The consequence of this limited weight loss is that compensatory weight loss must then be achieved during the last days of incubation, by maintaining very low settings - 40 % or even less of relative humidity. However, if climate in the setter and/or hatcher is very dry during the final days of embryonic development, water will evaporate not only from the egg shell and shell membranes, but also and undesirably from embryonic tissues like the skin and legs.

Advice

- Aim for 12 per cent total weight loss from initial egg weight during the first 18 days (between 0.6-0.7 % per day) for optimum chick quality.
- Start opening the air inlet gradually after four days of incubation to avoid relative humidity becoming too high, as this will require relative humidity to be kept low during the last days of incubation to achieve the desired 12 per cent weight loss at day 18.
- Use either a fixed relative humidity set point of 50 – 55 % or alternatively allow a gradual decline from 60 % to no less than 45 %, to allow sufficient evaporation of water from the eggs. Finetune set points based on chick quality, hatchability and/or achieved weight loss
- Increase relative humidity during the last days of incubation if chicks, shells and shell membranes show signs of dehydration. Dehydrated chicks show dried scales and shanks and the muscles on thighs and drumstick feel small.

Adjusting ventilation



Reducing ventilation at the start of incubation generally avoids the inlet of cold air. Because moisture is trapped in the closed incubator, the humidifier cold spot is also absent. Consequently closing the valves during the first days improves temperature homogeneity and heat transfer to the eggs, producing a good, uniform environment for continuing embryonic development – and an ideal start for achieving a narrow hatch window.

However at the same time, hatchery managers are aware that total weight loss may be challenged if ventilation is closed for too many days, with the result that relative humidity levels become too high. This is especially true in climates typified by high humidity.

For optimum chick quality, high (above 75 %) relative humidity during the first seven to 10 days should be avoided, because this forces compensatory weight loss during the last days of incubation through low settings (40 % or less) of relative humidity. The latter may affect hatchability and chick quality, because the very dry atmosphere during the final days in the setter will force evaporation from the allantois cavity and embryonic tissues like the skin and legs.

It is generally accepted that eggs should lose 11-13 % of initial weight during the first 18 days of incubation, for optimum hatchability and chick quality. Hatching egg weight loss is a result of the continuous evaporation of water from the eggs - and inseparable from the function of ventilation, which facilitates the removal of moisture from the incubator.

Since eggshell is porous, the release of (water) vapour from the egg starts immediately after laying, continuing throughout egg handling, storage and the incubation of the eggs. Evaporation from the eggs - and thus weight loss - is mainly a physical process, driven by differences between internal and external vapour pressures. Internal vapour pressure is mainly represented by the saturation vapour pressure in the air cell, which increases as temperature increases - thereby facilitating increased evaporation (weight loss) at a certain relative humidity. In environments with high humidity, weight loss is limited. So for example if relative humidity in the setter reaches 75 %, the daily weight loss of the eggs is only half of the weight lost from eggs placed in a setter with 50 % relative humidity.

We can conclude, that closing ventilation for the first three to four days of incubation is beneficial, supporting uniform embryonic development for each egg in the incubator to facilitate a narrow hatch window. Subsequently, ventilation should be opened gradually to support optimum daily weight loss, by the continuous removal of moisture from the eggs.

Advice

For setters with programmed valve positions

- Start to ventilate at a low level after 3-4 days of incubation to avoid relative humidity being higher than set point for too long.
- Set relative humidity at 50-55 % to achieve optimal weight loss. A gradually declining set point, from 60 % to no less than 45 %, will also deliver good results.
- Do not ventilate unnecessarily: open valves always disturb the internal incubator climate, which affects humidity, CO₂ and temperature distribution.

For setters with automatic controlled valve positions

- Set relative humidity at 50-55 % (or a gradual decline from 60 % to no less than 45 %) and maximize the CO₂-level at 0.4 %.

Incubation at high altitudes

The effect of high altitude on hatchability and chick quality depends largely on the altitude at which the hatching eggs are produced - and how the hatchery manager adjusts the incubation programme. Barometric pressure declines with altitude, as does the partial pressure of oxygen and absolute humidity. Because molecules move more freely at lower density, the overall diffusion of oxygen, carbon dioxide and water molecules through the pores of the egg's shell is increased. Moreover, fresh ventilating air at altitude is usually colder and drier than at sea level.

Oxygen availability

The reduced availability of oxygen in a given volume of air is partially compensated both by the increased rate of diffusion of oxygen through the shell, and by the embryo's higher capacity for binding oxygen to blood haemoglobin (Dragon et. al, 1999). Oxygen injection to artificially raise the oxygen level to 23 – 25 % may improve hatchability, but it is an expensive practice, that increases fire risk in the hatchery.

Water loss

It is reasonable to assume that the increased rate of diffusion at altitude will produce increased moisture loss from the eggs. However, evidence suggests that breeder flocks may adapt to altitude by producing eggs with a lower effective pore area, similar to the adaptation of wild birds to altitude. This compensates for increased diffusion, such that water vapour loss through the egg shell at any altitude remains the same as at sea level (Rahn et. al, 1977). Relative humidity set points for setter and hatcher should be chosen with care.

Three 'altitude' scenarios:

1 Eggs produced at sea level: hatchery at altitude (1000 - 2000 meters)

Of the three scenarios, this is the least desirable because it will definitely result in reduced hatchability. Eggs produced at sea level have a relatively large effective pore area and will therefore lose more water at higher altitudes. To compensate, setters and hatchers should be operated at a higher relative humidity. This is best achieved by pre-conditioning the inlet air to a relative humidity of 75 per cent, with a temperature of 24 - 28 °C (optimum). At the same time, increase the ventilation rate from normal for sea level, to accommodate the reduced oxygen levels.

2 Eggs produced at same altitude as hatchery (1000 - 2000 meters)

In general this will give good results. Ventilation rates should be higher than normal for sea level, such that the embryo is provided with sufficient oxygen. During humid external conditions, increase ventilation, as humidity reduces oxygen levels in the air still further. This higher ventilation rate may cause reduced humidity in the setters and hatchers. To avoid constant humidifying, humidity set points should be lowered. The higher than optimal weight loss (eg. 13 – 14 %) that results is preferred in this case.

3 Eggs produced at altitude: hatchery at sea level

Generally, this will give good results. The set points for relative humidity need to be reduced to achieve optimum weight loss, as the eggs have a reduced effective pore area.

Advice

- Fine-tune relative humidity set points by weighing trays of eggs before setting and again at transfer at 18 - 18.5 days. Exact set points for relative humidity are dependent on a.o. altitude and egg shell conductivity (age flock, nutrition, genetics). Optimum weight loss for good hatchability and chick quality is indicated in the table below.
- Judge the size of the air cell as an indicator of weight loss.
- Be aware of signs that indicate insufficient weight loss and/or a shortage of oxygen during an egg break-out. If too many wet, fully developed embryo's that fail to pip are observed, reduce set points for relative humidity and/or increase ventilation rate.
- Ensure that humidity and CO₂ sensors are calibrated for altitude, or alternatively find the correct set point to be used.

Optimum weight loss for good hatchability and chick quality based on our experience

Age breeder flock	Optimum weight loss
Young flocks	10 - 11 %
Medium flocks	11 - 12 %
Old flocks	12 - 13 %



Broody hens provide optimum conditions for embryos developing in the eggs they are sitting on. The brood patch provides heat from one direction only, and the eggs at the side of the patch are cooler than those in the middle of the nest. However, because the broody hen regularly turns and moves the eggs in the nest, uniform egg temperature is achieved.

In commercial incubation, we try to mimic the natural conditions in the nest. From the point of view of uniform egg temperature turning of eggs seems to be of less importance in modern incubators. Are there other reasons for turning eggs?

As summarized by Deeming (2002), egg turning is essential to normal development for several reasons.

Egg turning:

- Prevents adhesion of the embryo to the inner shell membrane.
- stimulates the rate of development of the area vasculosa (the membrane which grows around the yolk and is rich in blood vessels). The area vasculosa is important for sub-embryonic fluid formation, as well as for yolk uptake later in incubation.
- allows normal transfer of albumen proteins into the amniotic fluid, promoting optimum use of the albumen.
- supports the growth of the chorio-allantois (the blood vessels right under the shell) to maximise oxygen absorption.
- embryos in unturned eggs grow at a lower rate compared to embryos in eggs turned each hour over 90°.
- facilitates movements of the embryo into the normal hatching position and reduces the incidence of malpositions in unhatched embryos.

Recently Elibol and Brake (2004) confirmed the finding of New (1957), that the most critical period for turning broiler hatching eggs is during the first week of incubation. Elibol and Brake observed differential effects due to an absence of turning between 0 to 2 days (primarily increased early mortality) versus 3 to 8 days (primarily increased late mortality).

The effect of not turning during the first half of incubation is only seen during the second half of incubation, but by then it is too late to take corrective actions. Turning failures during the second half of incubation will generally have less dramatic effects, although the growth rate of the embryo can be affected, depending on the moment and duration of the turning failure.

The angle through which the eggs are turned is important. Hatch of fertiles was significantly better in eggs turned over an angle of 45° either side of the short axis of the egg, as compared to turning of 30° and 15°. Hatched chicks from eggs turned 45° weighed more and had less dry matter in the residual yolk. (Cutchin et al, 2007)

Advice

- Check the turning device before the start of each incubation cycle, as turning failures, depending on the moment of occurrence, are detrimental to results.
- Check and maintain the turning device regularly, to prevent a breakdown during incubation.
- Make sure that turning does not produce shocks or jolts, as this adversely affects hatchability and chick quality.
- If necessary, check and adjust the turning angle: 45° is optimal.

- Not turning for the first 12 hours in the setter is advised, based on our practical experience and especially when eggs are transported to the hatchery on the same day as setting. Eggs need some rest time to restore their 'internal balance'.
- Turning is not absolutely necessary after 15 days of incubation. Especially in incubators with insufficient cooling capacity, it can be beneficial to leave the eggs in a horizontal position to facilitate increased air flow (cooling over the eggs). In some modern setters, there is also the option of turning to three different positions, e.g. 45 minutes each in right, horizontal and left position).

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Elibol and Brake (2004). Identification of critical periods for turning broiler hatching eggs during incubation British Poultry Science Oct; 45(5): 631 - 637.

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Circadian Incubation™ - a new feature of single stage incubation

We know that a combination of genetic and environmental factors shape the embryonic body as well as the formation and maturation of functional tissues and organs. While the genetic make-up of the chicken embryo contains basic instructions for the development and formation of the body, developmental fine-tuning occurs through the interaction of environmental factors and the expression of genes.

In chicken, embryonic differentiation starts during egg formation and continues in the incubator, after a period of cooling and storage of the eggs. At the end of the second week of incubation, the embryo has almost reached its final size and shape. In this phase of development, differential gene expression guides the maturation of physiological control circuits. The maturing embryo is sensitive to environmental stimuli such that physiological control systems can be trained or 'adapted', to cope with stressful environments for the long term.

It has been proven that incubation temperature influences the expression of genes involved in the maturation of body temperature control. Chronic, continuous temperatures that are too high or too low negatively affect maturation. Conversely, short, daily temperature stimuli (Circadian Incubation™) produce long-lasting effects by training or 'imprinting' the thermoregulatory system – and it has been shown that training the thermoregulatory system during the maturation phase reduces the basic metabolic needs of the growing chicken. Temperature training induces a lowered body temperature at the thermoneutral zone - and thereby the amount of nutrient required to maintain the chick's body temperature.

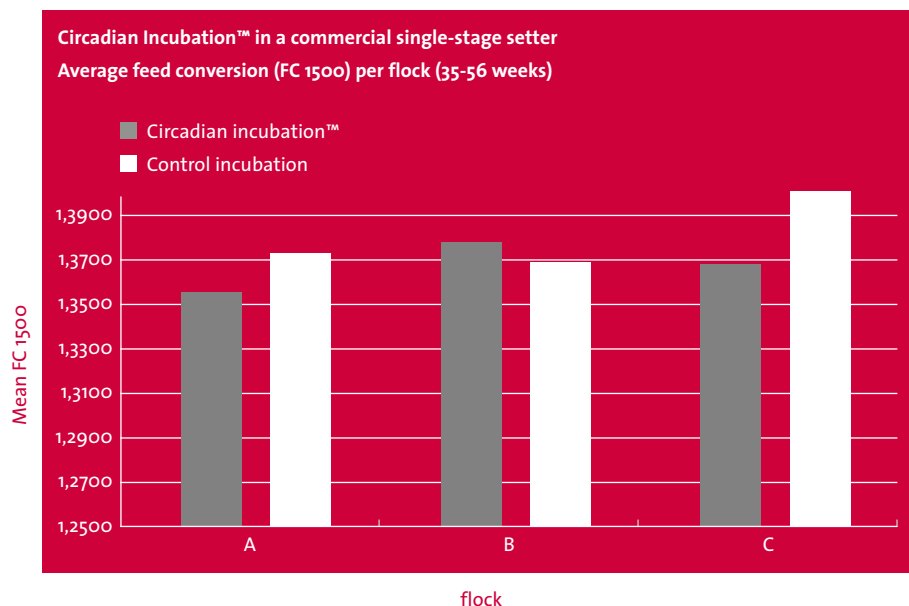


Figure 1. Average feed conversion rates (FC 1500) of broilers from three different breeder flocks. For each flock, four different Circadian Incubation™ cycles were performed in a large scale commercial single stage incubator. For each flock, experiments were performed at flock ages 35, 42, 48 and 56 respectively. For both Circadian™ and Control incubation, the growth and feed consumption of 4560 chicks were followed for 35 days.

Consequently, short daily temperature stimuli have a positive effect on economical parameters, such as hatchability, robustness, final bodyweight and feed conversion ratios. Temperature stimuli applied during the embryonic maturation phase also have a long lasting effect on resistance to heat stress in adult birds. However long lasting adaptation by Circadian Incubation™ only occurs if temperature stimuli are applied during critical, sensitive phases of development. In the chicken, this is during the final days of incubation, and further investigations are being carried out to define the optimum intensity and length of temperature stimulations for different egg types.

Circadian Incubation™ has already demonstrated positive affects on hatchability and feed conversion rates in commercial hatcheries and broiler farms, although interaction with breeder farms limits routine application. Figure 1 shows the variability in feed conversion rates in chicks hatched from eggs produced by different breeder farms. Future investigations will help to further understand the variable responses found in commercial practice.

Advice

- Optimize hatchery results using Circadian Incubation™ if single stage incubation practice is routine in your hatchery.
- Ensure accurate climate control in setters, to promote optimised temperature uniformity and sufficient cooling capacity that the incubation temperature can be reduced quickly and uniformly at the end of each temperature stimulus.
- Start Circadian Incubation™ on day 16.5 (2 hr at 100 °F set point) and continue through days 17.5 and 18.5 (1 hr at 100 °F) of incubation.
- Evaluate the results of Circadian Incubation™ in the hatchery and on the farm for each batch of eggs separately.
- Find the optimum length of temperature stimulation by undertaking trials on different batches of eggs of differing quality.
- Evaluate hatchability, chick quality and farm results after each trial of Circadian Incubation™.

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To candle or not to candle, that's the question...



During the incubation process, eggs are candled to determine the number of infertile eggs and eggs with dead embryos, together indicated as 'clears'. This can be done as early as day 5 - 6 of incubation by an individual candling light, but it is time consuming – and the risk of candling errors (e.g. accidentally removal of an egg with a normal living embryo) is evident.

The risk for candling errors is reduced if candling is performed at day 9 or 10 of incubation. By this time, it is also possible to use a so-called 'candling table', whereby the entire setter tray is illuminated from beneath. Using a candling table is less time consuming than using an individual candling light – though at the expense of accuracy. Because when the number of 'clears' is high, light escaping through the empty places – or 'flooding' – in the setter tray makes it more difficult to identify remaining clears conclusively. In many hatcheries, it is therefore common practice to candle eggs on the day of transfer to the hatcher, as this is most efficient in terms of time and labour productivity. When eggs are checked in this way at the point of transfer, automatic candling equipment that illuminates all eggs before the clears are removed, may be used without the disadvantage of reduced accuracy by light flooding.

There are several reasons for candling:

- 1 Early detection of problems on breeder farms, during egg handling and incubation, especially if combined with egg break-out.
- 2 Creating a set of hatchery specific reference data, in combination with egg break-out.
- 3 Estimation of expected percentage viable chicks.
- 4 Reduction of hatchery waste. In some cases, clears have a market value, whereas take off fees are incurred for waste handling unhatched eggs.
- 5 Positive impacts on hatchability and chick quality.

For reasons 1-3, it is sufficient to candle a representative number of eggs set. For reasons 4 and 5, all eggs should be candled and clears removed.

The work of Reis et al (1993) showed improved chick quality as a consequence of clear egg removal during candling, especially with older flocks. Studies by Embrex Inc. (IHP Volume 17 Number 7) also favour the removal of clear eggs during transfer and prior to in ovo vaccination. This trend appears to be stronger in the case of older flocks – a factor also supported by the results of Pas Reform Academy's work with customers in the field – and by experienced hatchery managers.

Clear eggs transferred to the hatcher create an unstable climate in the hatcher baskets, because they do not produce metabolic heat. When automatic chick separators are used, clear eggs are liable to break, causing 'painted' chicks.

Advice

- Do not candle between 11 and 14 days of incubation, as it interrupts the movement of the embryo to the length axis of the egg.
- When candling on day 9 or 10, empty places on the setter tray should be filled up by moving the remaining eggs backwards to create complete rows, leaving the first rows empty.
- Remove clears when higher than 10 - 15 %. When the percentage of clears is lower than 10 %, there is no direct need to remove clears prior to transfer.
- If during candling at day of transfer more than 30 eggs are removed from a setter tray with 150 eggs, add eggs from another tray to ensure each hatcher basket is full. Ideally, eggs should touch each other while laying in the hatcher basket; it seems the vibrations caused by first chicks to pip are a trigger for other chicks to start pipping as well.
- Record the number of clears and consider running an egg break-out on a representative sample.

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When and how to transfer eggs to the hatcher



Traditionally, setting and hatching occurred in the same incubator, with new eggs being set twice weekly. Generally, hatching baskets were situated at the bottom of the incubator, where temperatures were lower. But this system was not successful in terms of maintaining egg hygiene, as the fluff from hatched chicks contaminates unhatched eggs, and the system did not facilitate proper cleaning and disinfection. It was also impossible to create optimal climatic conditions for eggs of various setting dates and the newly emerging chicks at the same time.

Today, it is common practice to place eggs in the setter for the first 18 days, before transferring them to the hatcher for the last three days of incubation. Generally, this occurs between the embryonic ages of 17 days and 12 hours and 18 days and 12 hours, to coincide with the normal working schedule of the hatchery (see table), whereby hatchers are used twice a week.

In this scenario, incubation time is measured from the (assumed) moment the eggs reach optimum internal temperature for embryonic development, and not from the moment the eggs are placed in the multistage setter or from the moment the single-stage setter is switched on. Depending on the setting system, heating capacity and initial egg temperature (in relation to the method and duration of preheating) corrections must be made if one wants to express incubation times from machine start-up. For example, in the table, corrector time equates to six extra hours.

Fluctuations in production planning may dictate transfer either earlier or later than in normal practice.

Transfer to the hatcher can happen as early as 15 days (= 360 hours of incubation), as there is no evidence to suggest that stopping turning after 15 days of incubation in domestic fowl has any deleterious effects on development and hatchability (Deeming, 2002). However, it is our practical experience that transferring to the hatcher at this moment can reduce hatchability by 0.5 - 1 per cent.

Transferring to the hatcher should not occur after 19 days (456 hours) of incubation, because disturbing the eggs at this time adversely affects the act of internal pipping.

Advice

- Transfer eggs after 17 days and 12 hours of incubation to the hatcher, but not later than 19 days (= 456 hours). Only in exceptional or unavoidable circumstances, should eggs be transferred as early as 15 days (= 360 hours).
- Adjust hatcher climate in relation to the age of embryos, if transfer must occur before the recommended minimum of 17 days and 12 hrs. In practice, the setpoints of the setter should be

followed. However as there is increased airflow over the eggs once they are positioned horizontally in the hatcher baskets, it may be necessary to increase setpoints by, for example, 0,2 °F.

- Maximise the time from setter to hatcher to 20 - 30 minutes.
- Maintain a good climate in the transfer room (approx. 25 °C and avoid draught).
- Leave the setter switched on as long as there are still eggs inside! Failure to do so will impede the cooling of the eggs, which is likely to produce late mortality due to overheating.
- Empty setter trolleys from top to bottom, to avoid exposure to high temperatures in the topmost trays as a result of rising heat from the embryos in the lower trays.
- Handle the eggs carefully during transfer. Eggs cracked during transfer have reduced hatch potential due to dehydration.
- Make sure the hatcher baskets are dry.
- Fill the warmed hatcher with trolleys according to the manufacturers recommendations. This is particularly important when the hatcher is not filled to capacity.

Working schedule for hatchery with 4 hatch days per week, whereby weekend workdays are avoided. The 1st hatch and 3rd hatch are in the same hatchers. Incubation time is measured from the moment internal egg temperature has reached optimum incubation temperature.

Time	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
6.00	1 st hatch (21 d + 6 h)	2 nd hatch (21 d + 6 h)		3 rd hatch (21 d + 6 h)	4 th hatch (21 d + 6 h)		
12.00	3 rd transfer (18 d + 12 h)	4 th transfer (18 d + 12 h)		1 st transfer (17 d + 12 h)	2 nd transfer (17 d + 12 h)		
18.00	2 nd set		3 rd set	4 th set			1 st set
24.00	2 nd start (o)		3 rd start (o)	4 th start (o)			1 st start (o)

Hatcher basket hygiene for a clean start



The hygiene status of the environment into which chicks are hatched has a direct impact on day-old-chick quality and first week mortality.

The first environment encountered by the chicks is the hatcher basket and its contents. Hatcher baskets are used intensively, often twice a week. Keeping them scrupulously clean between cycles will pay dividends.

Weak egg shells combined with breakage due to rough handling during transfer can smear the chick's down – and these chicks are often culled, to avoid customer complaints. Exploding eggs, due to contamination, expose the newly hatched chicks to a high bacterial challenge. In suboptimal incubation conditions, chicks that hatch without a fully closed navel are most vulnerable, as this forms a point of entry for pathogens that will lead ultimately to increased first week mortality by yolk sac infection.

Eggs should be transferred in properly cleaned and disinfected hatcher baskets. Dirt left behind from a previous hatching cycle, such as meconium (the greenish droppings produced by the chicks), pieces of eggshell, fluff, blood and egg contents, should be thoroughly removed prior to disinfection.

Hatcher baskets are best washed directly after the removal of chicks and hatch residue. Washing hatcher baskets manually with a scrubber, or semi-manually with a high pressure cleaner, can give results that equal washing in a purpose-designed automatic washing machine, but it is very labour intensive. In more sophisticated automated washing

systems, a stacking and destacking module allows pre-soaking time, for thorough, easier cleaning.

Other measures for optimised cleaning and disinfection are:

- **Temperature:** washing water should be not higher than 50 – 60 °C, to prevent the coagulation of proteins. At minimum, 40 °C will give adequate cleaning results.
- **Detergent:** use an alkaline-non foaming detergent (with or without hypochlorite) at the recommended concentration, alternating occasionally with an acid detergent, to prevent the build-up of scale.
- **Mechanical effect:** Maintain the pressure and direction of the washing water; e.g. quality of nozzles and proper adjustment. Higher pressure gives better results.
- **Time:** The speed with which the hatcher baskets pass through washing; slower transit produces better cleaning results.
- Rinse thoroughly with clean water.
- Follow washing with disinfection, using a broad-spectrum disinfectant.

A hatcher basket manufactured to include a microbiological agent in the polymer from which it is made provides continuous protection between cleaning cycles.

If the washing process gives good cleaning results, there is no benefit to using paper in the baskets, unless the batch includes many exploders. In this case, the paper will absorb some of the mess and the chicks are more likely to stay clean. The use of paper with high absorbency and enough grip for the chicks to avoid “splay legs” is recommended.

Newspaper is not suitable. If paper is used, check that it does not hamper air flow over the eggs and hatched chicks by making sure that it fits inside the base of the basket - and cover entirely with eggs, to keep it down.

Advice

- Clean and disinfect hatcher baskets thoroughly after every use.
- Evaluate cleaning results regularly by visual inspection and take corrective action when needed.
- Monitor the effect of disinfection by taking staking swabs or Rodac-plates.
- Allow baskets to dry thoroughly before the next transfer; consider an extra set of hatcher baskets if this cannot be achieved.
- Consider whether to use paper in the hatcher baskets carefully: incorrect use will have a negative impact on airflow and could affect hatchability and chick quality.

Creating the ideal hatching climate



The transfer of eggs from setter trays to hatcher baskets is routine in the hatchery, while the embryo continues to develop. In the final days of incubation, the embryo prepares for hatching and while embryonic growth slows down at this stage, the maturation of most of the organs continues.

The embryo turns its body along the long axis of the egg, with the beak under the right wing and the neck bent towards the blunt end of the egg.

Residual yolk is retracted within the abdominal cavity and the navel closes. Simultaneously, blood flow through the chorion allantois membrane ceases – and the chick uses the egg tooth to penetrate the inner membrane of the air cell.

Exposure to this gaseous environment in the air cell stimulates the lung and air sacs to be filled. And after a period of time, the chick pierces a small hole in the egg shell, defined as external pipping.

Time elapsed between internal and external pipping varies according to breed, flock ages, storage and incubation conditions in the setter. However, it has been shown that external pipping is triggered by the partial pressure of carbon dioxide in the air of the air cell (Visschedijk, 1968a).

The higher the partial pressure of carbon dioxide, the shorter the interval between internal and external pipping. External pipping is known to be delayed in porous egg shell or by a hole in the egg shell (Visschedijk, 1968b).

Hatching is a stressful and critical period, influenced by the physiological condition of the chick as well as by climatic conditions in the hatcher. If, for example, energy stores in the embryo are low because of poor climate conditions during the last days of setting, the fully developed chick dies shortly after external pipping.

If, during external pipping, humidity in the hatcher is lower than 70 per cent, the shell membranes dry out, leaving the chick stuck in the egg.

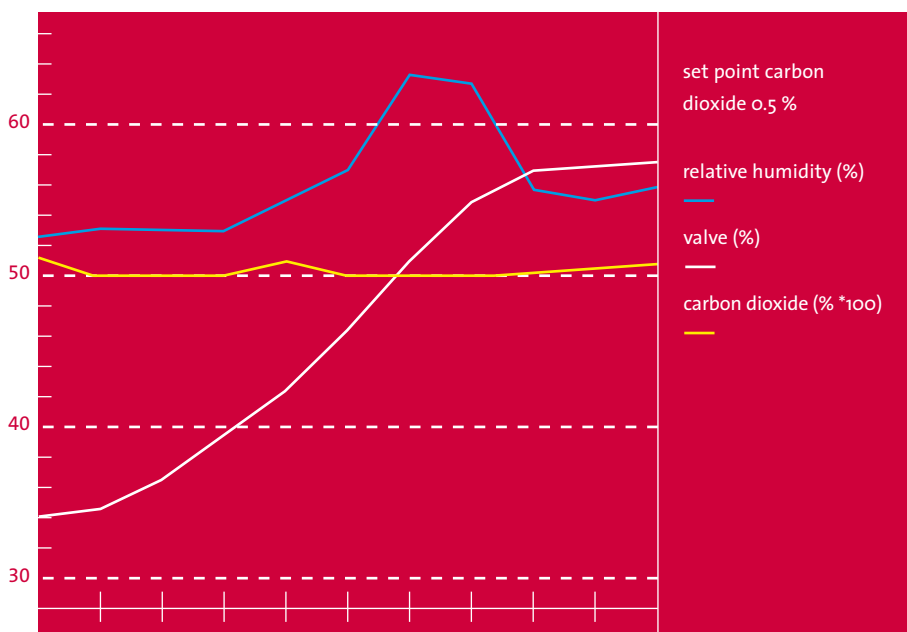
When temperature is too low, chicks chill during drying - and when carbon dioxide levels are too high, the chicks will gasp for fresh air when they have hatched and dried.

Advice

- Control ventilation based on carbon dioxide (CO₂) levels. CO₂ set points of 0.5 % +/- 0.1 are recommended as optimum for high hatchability and good chick quality.

- If the valves are controlled by CO₂ levels, humidity will rise automatically when the first chicks hatch (see figure).
- Humidity will decrease when most of the chicks have hatched and dried. If using a SmartHatch™ hatcher, the hatcher's display panel will read: 'chicks are ready to be pulled'.
- Do not lower the temperature before all chicks have dried.
- If the hatch window is longer than 24 hours, review the management of setting. The hatch window will become larger when batches of eggs from different flocks and storage conditions are mixed in one setter and hatcher.
- If the hatch window is longer than 24 hours, review the temperature distribution in the setter. In general the hatch windows will be larger after multi-stage incubation compared with single-stage incubation, because temperature distribution in a multi-stage incubator is not homogenous.

Automated Hatching System



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Managing the hatch window



The term 'hatch window' is used to describe the time span between the hatching of the first and the last chick in one particular hatcher. However in practice, because it is impossible to look inside each and every hatcher basket without compromising the hatcher climate, the hatch window is estimated rather than measured precisely.

If the hatcher has a window, the measurement of the hatch window begins with sight of the first chicks. Another good indication is an increase in relative humidity. Once the first 5 - 10 % of chicks emerge from their shells, the moisture on their bodies quickly evaporates, which drives relative humidity upwards spontaneously.

It is possible to stop and open the hatcher at (e.g.) minus 36, 24 and 12 hours before planned chick take-off, to estimate when the first chicks appeared. But this method does interfere with climatic conditions, and estimations are often crude, based on observations from a sample of hatcher baskets by quickly opening the hatcher. Using this method, timing the appearance of the last chick will often vary from hatchery to hatchery. And consider too: the last chick may never in fact hatch in the case of, for example, an externally pipped egg – complete with a still living, fully developed embryo – that fails to finish the job due to malpositioning.

Chicks do not hatch at exactly the same time. Even if two hatching eggs receive the exact same pre-incubation and incubation treatment, they still may differ a few hours in incubation time, because of natural variation in embryonic development. In normal day-to-day practice, eggs placed together in one particular hatcher almost certainly do not have the same history.

Factors like egg size, flock age, post-lay egg cooling profile and storage times do all have an effect on incubation time.

The most crucial factor for the rate of embryonic development – and thus determining incubation time – is temperature. The hatchery manager must ensure that hatching eggs have the same or very similar characteristics before placing them in the incubator. Once inside, uniform conditions, especially uniform temperature distribution, are essential to achieve a short hatch window.

With good management and modular, single-stage equipment, it is possible to achieve a hatch window of 12 - 24 hours for broilers. In any case, the hatch window should not exceed 24 hours (see figure). This prevents dehydration in chicks that hatch first. Subsequently, ensuring that all the chicks – from first to last in the hatch – gain access to their first feed at the same time – or as closely as possible to simultaneously, is important for maintaining post-hatch uniformity. Careghi et al. (2005) showed that delaying access to feed after the hatch depresses the relative growth rate of chicks differently for early versus late hatched chicks.

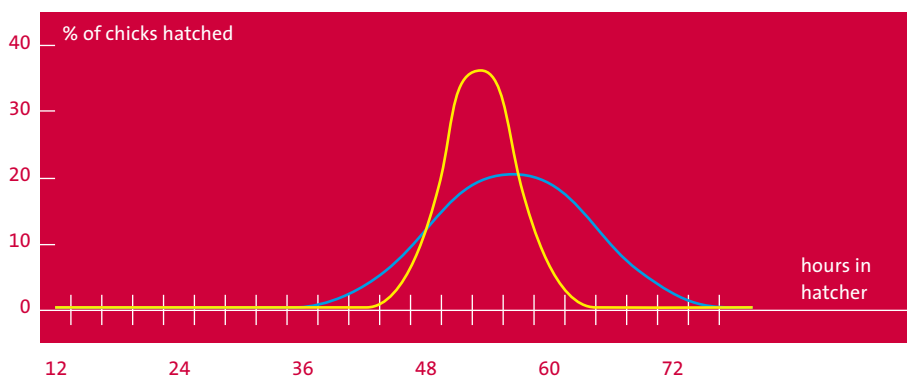
When using modular single-stage incubation methods, the hatch window for

commercial layers is usually even shorter than for broilers, at just 8 - 12 hours.

Advice

- Fill the setter with similar batches of eggs pertaining to breed, maternal age, egg size and storage time.
- Transfer batches of eggs from one big setter to several smaller hatcher, keeping each batch with similar characteristics within one hatcher.
- Preheat eggs for 5 to 8 hours at 25 °C (77 °F) in the setter. Alternatively, pre-warm eggs in the setter room for a minimum of 12 hours, to ensure uniform internal egg temperature prior to the onset of incubation.
- Ensure fast, even warm-up to incubation temperature by using setters equipped with sufficient high heating capacity. Incubation set point should be achieved within 5 - 6 hours, providing eggs are properly preheated or prewarmed.
- Aim for uniform incubation conditions, especially temperature. This is best achieved in modular single-stage incubators, designed for uniform temperature distribution, with the functionality to deliver different temperature set points per batch of eggs.

For broilers, a reduced hatch window of 12 - 24 hours (yellow line) is achievable with good equipment and good management.



Incubation times in the modern hatchery

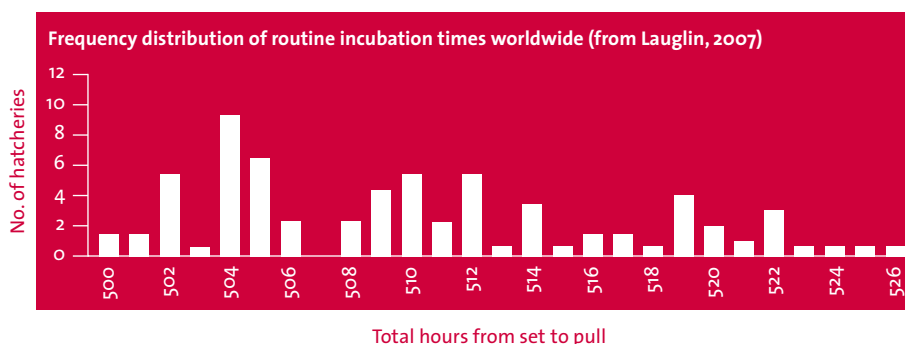
The chicken embryo generally needs 21 days (504 h) to complete incubation, including the drying of down (Etches, 1996). In practice however, incubation periods vary considerably, as observed by Laughlin (2007) in large scale field surveys, which recorded pulling times from the setting of eggs of 500 up to 526 hours (figure 1).

This variation can partly be explained by differences in the time required to heat the eggs from room temperature to incubation temperature (100 ° F), either due to initial egg temperature and/or the different heating capacities of incubator types.

Incubation time also varies because the growth rate of the embryos differs between batches of eggs. Flock age and egg storage are the best-known parameters for influencing embryonic growth rate and, thus, hatching times. As a general rule, eggs stored for more than five days need one hour more incubation time per day of storage.

Eggs from peak production flocks hatch earlier than eggs from younger or older flocks. This observation from practice is confirmed by small scale experiments published in several scientific papers, whereby the average incubation period for different broiler lines varied between 498h for flocks of 35-45 wks of age and 508 h for younger (<30 wks) and older (>55 wks) flocks.

There may be two distinct explanations for the shorter incubation time of eggs from peak production flocks. Firstly, higher fertility in these eggs means that the number of heat producing eggs on the single tray is increased. This may result in higher average embryo temperatures, inducing accelerated development and therefore an early hatch. Secondly, hens in peak production are of optimum



physiological reproductive age. They produce good quality eggs and embryos that grow at an optimum rate, which may result in an early hatch.

Single stage incubation enables the finite control of embryo temperature and thus hatching time. In contrast to the management of incubation temperature, the opportunity to influence egg specific factors, such as flock age or egg size, is limited. However, based on experience, the hatchery manager can tailor egg specific programs using single-stage incubation.

Knowing the correct incubation time from setting to hatching is important for planning optimized chick take-off. In practice, incubation times can vary not only between different hatcheries – but also within hatcheries, between different batches. Pulling times and future setting-times, should therefore be fine-tuned based on observation – making an observation-window a very practical and useful feature in the hatcher.

Optimal pulling time can also be shown on the display of the hatcher, when this feature is available, using software that reads the naturally evolving humidity peak inside the hatcher to trigger a so called 'hatch alert'.

For optimal chick quality, pulling should occur when 90-95 % of the chicks are completely dry, with 5-10 % almost dry except at the neck. Chicks collected at the

optimum time point show no signs of dehydration or feather development, while dehydrated chicks are inactive, with thin legs and dry-looking scales.

Advice

- Pull chicks at the correct time for optimum chick quality.
- Plan the start of the incubation cycle such that chicks are ready for take off at 504 ± 2 h. Accommodate variance in hatching times within and between hatcheries.
- Decide on the actual take-off time by observing the hatched chicks at 500 hours. This is especially important when fresh eggs from peak production flocks are incubated;
- Be flexible in choosing the first hatcher to be pulled: trust observation over routine. When 5 %-10 % of the chicks in a tray are still wet around the neck, the hatch is ready for take-off;
- Adjust setting times for subsequent cycles based on continuous observation and data analysis from previous incubation cycles, taking egg type, flock age and storage time into consideration.

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Optimum timing for pulling day old chicks



The length of the incubation period is influenced by several factors:

In general terms, the time needed to complete development from a day one embryo to a day old hatchling depends on the species. The chick embryo hatches after 21 days of incubation, while turkey and duck poults hatch after 28 days. However, within each species, the duration of incubation and thus the pulling time varies between different batches of eggs.

Flock age is an inherent factor in determining hatching time. Embryos from flocks younger than 30 weeks may need an additional 5-7 hours to complete development, compared to older flocks. Incubation time increases again when flocks are older than 60 weeks.

Storage of the eggs also has a major impact on the length of the incubation period, probably because the albumen and yolk undergo physical changes during storage: prolonged periods of storage are known to be damaging to the early embryo. When eggs have been stored for periods exceeding three days, one hour extra incubation time should be applied for every additional day of storage over three days.

Incubation temperature is proven to be the most important external factor for determining the rate of embryonic development and growth. In turkeys, the hatching time increases by 6 - 8 hours, depending on breed and flock age, when the incubator temperature is decreased by 0.5 °C. For chickens, the incubation period increases by 4 hours per 0.5 °C decrease in temperature set point. However it is also important to note that when the incubator temperature is too high, in excess of 39 °C (102.2 °F) after day 16, the incubation period also increases.

With all the above taken into consideration, it is clearly impossible to standardise optimal pulling time. However it is clear that if chicks are pulled too early, too many chicks will be classified as *second class* because they are not completely dry. When chicks are left too long in the hatcher, the risk of dehydration increases – and with it, the risk of mortality in the first week. Furthermore, dehydrated chicks should be avoided at all times, because this has clearly been shown to adversely affect chick performance at farm level.

Advice

- Do not pull chicks 'on the clock'.
- Pull chicks when they are visually ready for take-off; i.e. when 95 % of chicks are completely dry and no more than 5 % are still damp on the neck.
- Crush some empty shells to judge the correct timing for pulling chicks. When the membranes crumble in your fist without falling apart into small pieces, the chicks were pulled at the right time.
- Use your observations during the pulling of chicks to finetune setting time for future batches.

Reconciling maternal (flock) age and chick quality

The expression 'chick quality' is a general term, often used by hatchery managers to describe the appearance of a batch of day old chicks. In this context, chicks deemed to be of 'good quality' are active with closed navels, a soft, smooth yolk sac, no red hocks and a clean beak. In such a batch, the birds are uniform in appearance and weight.

A main cause of non-uniform day old chick quality is variability in the quality of hatching eggs. Day old chick weight and quality is determined by flock age, with factors such as strain (genetic background) and weight loss during incubation also influencing the overall quality of the chicks.

Genetic selection for growth, lean meat and FCR is negatively correlated to reproductive efficiency. The management of broiler breeders to optimize the production of good quality hatching eggs is therefore more challenging now than in the past. Uniform egg size depends on flock uniformity - and therefore on pullet growth management, nutrition and lighting schedules.

As the flock ages, we see an increase in the weight of the eggs it produces and consequently, an increase in recorded day-old chick weight (table 1). An experienced hatchery manager knows that the quality of chicks will decrease when eggs are derived from aged flocks. This is often observed in higher numbers of chicks showing a bad navel and red hocks in batches from flocks older than 50 wks. Poor chick quality as the flock ages is also recognized by slower growth during the first week (table 1) or when evaluating the morphological parameters used to calculate the Pasgar@score for chick quality (figure 1).

The exact reason that day old chicks from older flocks are of reduced quality is not known, but it is most likely to be related to inadequate egg content and/or improper incubation conditions and/or pulling times. For example, in the routine of a hatchery, incubation times may not be adjusted to variable flock age. This may result in chicks that are too 'fresh' from very young (29 Wks) and very old (59 Wks) flocks, or dehydrated chicks from flocks in peak production, since chicks from very young and very old flocks hatch later than chicks from peak production flocks.

Advice

- Incubate batches of eggs derived from one flock in one incubator whenever possible.
- When different batches of eggs must be combined in one incubator, try to ensure that the eggs are from flocks of similar age.
- Pull chicks according to flock age: chicks should be dry but not dehydrated. Pulling time is correct if 5 % of chicks are still a bit wet, ie. With down feathers that are not completely dry, at the neck.
- Evaluate chick quality using a quality-score system such as the Pasgar@-score.
- Adjust the incubation program if chick quality is below your reference.

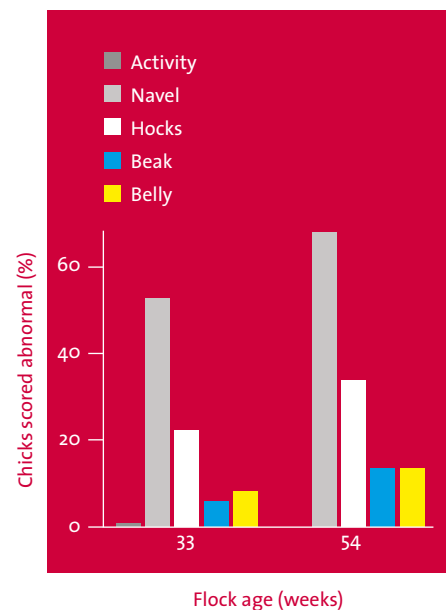


Figure 1: Evaluation of individual morphological parameters used to calculate the Pasgar@score of chicks from young and older flocks. Pasgar@score of chicks from older flocks is lower because the percentage of chicks with an abnormal reflex (black); navel (green); hocks (red); beak (blue); large yolk sac (yellow) is higher.

An example of production parameters related to age of broiler breeders

Age of Cobb broiler breeders (wk)	Egg weight(g)	Chicks scored for high quality (%)	Day-old chick weights (g)	7-d-old chick weights (g)	Relative growth up to 7 d (%)
35	66.4± 0.5	97.7± 1.3	45.2± 0.4	141.4± 2.0	206.9 ± 5.1
45	70.6± 0.6*	93.7± 2.2	49.4*± 0.4	140.4± 1.8	185.5*± 4.2

*Data significantly different ($P < 0.05$); Data from Tona et al, 2004: J. Applied Poultry Research 13:10

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Red hocks in day old chicks or poults



A day old chick is considered to be of good quality if it has the capacity to grow and mature in line with its genetic potential. The chick is alert and active, with a closed navel and well developed legs that are soft and well hydrated when the toes are extended or stretched. In addition the hocks of a first class chick will show no signs of swelling and be of normal skin colour. Conversely, chicks of inferior quality often show dehydrated legs with red, swollen hocks.

However in practice, many hatcheries do select chicks with minor abnormalities as saleable – and in these saleable batches, we often find chicks with small lesions on the hocks – often called ‘red hocks’.

This condition is attributed to poor conditions in the setter or hatcher. When humidity is set too high, many chicks hatch with an overly large belly, causing them to struggle to leave the shell. As the overheated chick thrusts with its folded legs against the shell, it will – in its bid to be free of its shell as quickly as possible – often thrust too violently, causing damage to its hocks in the process.

But do red hocks actually influence welfare and growth performance in the farm? In a small scale experiment, Pas Reform analysed the behaviour and growth of poor quality chicks with red hocks, black dots on the navel and a large yolk sac (De Jong et al, 2004).

In a commercial hatchery environment, 96 good quality chicks were selected as a control group, with an equal number of poor quality chicks. The chicks were housed on wood shavings in groups of four – two good quality chicks and two poor quality chicks – per pen. Both groups were studied and compared for two aspects of welfare (behaviour, walking ability) and for growth in relation to production, between days 1 - 8 and days 35 - 42 of age.

Significant differences between poor quality chicks, good quality chicks and broilers raised from them.

Parameter	Poor quality chicks	Good quality chicks	P-value (D)
Relative growth week 1 (%) (A)	215.4	225.1	0.03
Gait score day 39 (B)	0.84	0.49	0.01
Step with (cm) at day 39	9.55	8.61	0.006
Latency-to-lie at day 40 (min) (C)	210	263	0.06

Ad. A: Relative growth (RG) is calculated as follows: $RG = 100 \times (\text{weight day 7} - \text{weight day 0}) / (\text{weight day 0})$

Ad. B: Optimum gait score is zero when chicks walk normally for at least 10 steps (Dawkins, 2004)

Ad. C: The latency-to-lie test measures the time in consecutive minutes that the broiler is willing to stand.

Ad. D: P-values < 0.05 represent a significant difference between good and poor quality chicks.

This study established that good quality day old chicks suffer less from leg weakness than poor quality chicks – and that to avoid the incidence of chicks with red hocks, large yolk sacs and bad navels, incubation conditions should support optimal embryonic development.

Advice

To optimise results with day old chicks:

- Decrease relative humidity in the setter if many chicks (> 20 %) have a thick belly.
- Increase setter temperature by 0.2 °F, if red hocks are showing in combination with late hatches and many chicks (> 20 %) also have a thick belly.
- Decrease temperature in the hatcher by 0.2 °F if more than 15 % of saleable chicks have red hocks.

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Empty shells.

A valuable source of information

On hatch day, unhatched eggs, dead and culled chicks and empty shells are inevitably produced as hatchery waste. It is generally accepted that unhatched eggs and dead or culled chicks can be used to evaluate the incubation process, to help determine where improvements can be made. Empty egg shells are usually overlooked. But these also form a valuable source of information for the hatchery.

Empty shells can provide additional information about the pulling time of the chicks and their hatching conditions. When empty shells are crushed in the hand, the dryness of the shell membranes can be judged. Pulling time and hatching conditions are good if the membranes crumble in your fist without falling apart into small pieces. When the membranes completely stay together and do not crumble they are still too moist, indicating that the chicks were pulled too early. In this scenario, we expect also to see some partially wet chicks - or even externally pipped chicks still alive. The membranes falling apart into small pieces indicates that pulling time was too late or that relative humidity may have been too low during hatching, possibly due to excessive ventilation. If pulling time was too late, a lot of meconium (the greenish droppings produced by the chicks) will also be observed on the empty shells.

The height of pipping is an indication of weight loss during incubation. If weight loss was insufficient, the air cell remains small and the chicks are forced to pip high. Some chicks will not be able to pip at all and will drown inside the egg. The correct height for pipping is roughly at half, or just above half, the height of the egg. Exposed to ideal hatching conditions, the chicks will pip the rest of the shell neatly in a circular manner. Rough or incomplete pipping is an indication of sub-optimal hatching conditions.

At days 11 - 12 of incubation, the chorio-allantoic membrane reaches the sharp end of the egg. If the albumen sac is too large due to insufficient weight loss, this membrane cannot reach the sharp end and will not be closed. Insufficient weight loss is typically caused either by too low a temperature or over high humidity. Observe whether or not the chorio-allantoic membrane is closed by looking inside the bottom part of the empty shells. If there was overheating during the last days in the setter or in the hatcher, excessively thick and clearly visible blood vessels will be observed.

Advice

- Judge the accuracy of pulling time and hatching conditions by crumbling empty shells in your fist and by checking the amount of meconium on the egg shells.
- Check the height and manner of pipping, to judge whether weight loss during incubation was sufficient.
- Check the inside of the empty shells for signs of insufficient weight loss during the first half of incubation (blood vessels not reaching until sharp end of egg).
- Observe the inside of the empty shells for signs of overheating (excessively large and clearly visible blood vessels).
- Use information obtained from assessing the empty shells in conjunction with other observations, to avoid hasty or incorrect conclusions.

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Spray vaccination of day-old-chicks at the hatchery



Spray vaccination is the preferred method for administering respiratory vaccines, eg. for Newcastle Disease (ND) or Infectious Bronchitis (IB), especially when vaccinating birds for the first time.

Spray vaccination can be undertaken either in the hatchery or immediately after reception at the farm, while the chicks are still in boxes. Vaccinating in the hatchery is generally considered more effective, as the process is automated and therefore more controlled than the hand-spraying that tends to occur on the farm. Hatchery automated methods include either the use of a spray cabinet that is triggered each time a box of chicks is placed inside, or a spray vaccinator mounted over the conveyor line for chick boxes.

Vaccines suitable for spray delivery are live vaccines, produced by growing the required virus in incubated eggs or tissues cultures. After attenuation (=weakening), the viruses are freeze-dried and appear as a pellet in a glass vial containing 1,000 – 10,000 doses. This allows the vaccines to be stored under controlled conditions for several months until expiry date.

Prior to use, the vaccine is dissolved in water, after which it expires within hours and therefore must be used immediately. The water serves as a transport medium for the live virus to the day-old-chicks. Once sprayed, the vaccine will attach to the mucosa cells of the chicks' eyes and upper respiratory tract. Preening (= cleaning feathers with beak) optimises uptake. Once in the body, the virus will multiply inside the mucosal cells, to develop good local immunity in the respiratory tract.

When administering vaccines by this method, it is important that the spray is 'coarse', ie. that droplets are at least 100 – 150 microns in size. Any smaller and the vaccine will be inhaled too deeply into the respiratory tract, resulting in an excessive post-vaccination reaction. This presents as mild disease symptoms in the flock 3- 5 days after vaccination - and will have a negative effect on production.

Advice

- Store vaccines in a refrigerator kept for this sole purpose until use.
- Follow the manufacturer's instructions for use carefully.
- Ensure that the water used for diluting the vaccine is of good quality, not chlorinated and low in mineral content. Use demineralised water if tap water does not meet these criteria.
- Dilute vaccines in a bucket or vessel only ever used for this purpose. Any traces of eg. disinfectant will kill the live, attenuated virus and render the vaccine ineffective.
- Adjust the spray vaccinator according to the size of the chick boxes and the speed of the conveyor belt. Check regularly that no vaccine is wasted and that the total surface of the chick box is uniformly covered by spray e.g. by placing absorbent paper inside an empty chick box.
- Apply coarse spray only. Install a suitable nozzle and adjust pressure to achieve this.
- Record the batch number of the vaccine used. In the case of an adverse reaction, this will help the manufacturer to track the problem.
- Inform customers which vaccination birds have received at the hatchery. Spray vaccination that targets the same organs within 10 – 14 days should be avoided.
- Do not mix different vaccines on your own initiative. If different vaccinations are required, use only registered combinations formulated by the vaccine manufacturer and tested for compatibility.
- Leave chicks in boxes for at least 20 minutes after spraying, to optimise the effect of preening.
- Avoid placing wet chicks in a chick despatch room with a suboptimal temperature or draught.

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Maintaining the ideal climate for chick handling and transport



Good post hatch performance and low first week mortality can best be expected from chicks kept in ideal conditions between leaving the hatcher and placement in the farm.

When pulled, chicks leave an ideal climate, with hatcher temperature of approx. 97.5 - 98 °F (36.4 - 36.7 °C), relative humidity at around 60 per cent and air circulating at high speed. Movement to the handling room exposes the chicks to a very different climate. And boxed chicks are often kept for some time in the chick despatch room, before being transported to the farm.

Normal rectal temperature for a day-old chick is 40 - 40.5 °C (104.0 - 104.9 °F). Newly hatched chicks are dependent on climatic conditions to regulate their body temperature for the first few days. And good ventilation will drive excess body heat out of the chick boxes, while also preventing a build-up of carbon dioxide.

Chick behaviour is the best indicator of climatic conditions during chick handling and transport. Under ideal conditions, day old chicks breathe quietly through their nostrils, losing only a little water. They spread evenly in the boxes, make little noise and are relatively inactive.

If carbon dioxide levels are too high, the chicks will gasp for air and try to stick their heads out of the chick boxes. This blocks the passage of air into the boxes, so compounding the problem.

When environmental temperature is *too low*, or there is too much draught, the chicks huddle together to try to maintain body temperature. Chicks are especially prone to chilling if pulled too early ('wet chicks') or after spray vaccination.

Too high an environmental temperature causes chicks to open their beaks and pant, which evaporates water from their lungs and air sacs. Short term, panting will help the chicks to lose excess body heat, but it also leads to faster dehydration. When the chick's water reserve is depleted, this control mechanism becomes redundant. With further increases in environmental temperature, the chicks become progressively more noisy, spreading their wings to try to reduce body temperature. But if environmental heat remains excessive, this too will fail to keep the chicks' body temperature down – and inevitably some chicks will be lost.

Trying to prevent dehydration by increasing relative humidity only makes it more difficult for the chicks to evaporate water. Excessively *low* relative humidity also leads to dehydration.

Advice

Recommended post hatch climate settings are shown in the table below. Specific recommendations include:

- Look, listen and respond accordingly to the chicks' behaviour. It may help to record the rectal temperatures of a representative sample of chicks occasionally.

- Remember that the room and/or truck climate is secondary: it is the climate in the chick boxes that matters. Temperature at chick level should be approximately 32 - 35 °C (89.6 - 95.0 °F).
- Avoid chilling by pulling chicks too early or after spray vaccination – and beware of draughts!
- Reduce the number of chicks when temperature during transport and (un)loading is too high.
- To provide sufficient ventilation in the chick-despatch room, position the chick boxes in uninterrupted rows with 30 cm (min) between each row, and a fan blowing preconditioned air in alternate corridors between the rows.
- Ensure that trucks are loaded correctly, based on the ventilation principle of the truck-type.
- Review the output of 'climate loggers' from the chick boxes during transit: the temperature in the boxes can be between 8 - 14 °C higher than the air temperature in the truck.
- Have the driver measure and record climatic conditions, including floor temperature, in the receiving farm.
- Unload the chick boxes immediately on arrival at the farm, as the house temperature is high and ventilation is too low to drive the additional heat produced by the chicks out of the boxes.

Recommended post hatch climate settings

	Temperature (°C)	Relative humidity (%)	CO ₂ (ppm)	Air flow
Chick handling and dispatch room	22 - 28	50 - 60	500 - 600	Sufficient
Truck	22 - 28	50 - 60	500 - 600	Sufficient
Farm	Air: 32 - 35 Floor: 28 - 30	50 - 60	500 - 600	Negligible

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Improving transport performance



The transport of day old chicks from hatchery to farm has a critical role to play in subsequent performance. Hatcheries operate in a fully controlled indoor environment, while transport entails the risk of exposing the chicks to uncontrolled, outdoor conditions. The modern hatchery is a major investment in state-of-the-art science, technology and engineering. It therefore makes sense to create a professional, modern chick transport fleet, specifically designed to maintain an optimised environment, to ensure that the birds arrive at the farm in the same condition in which they left the hatchery. Day old chicks are naturally well equipped for transport. Born with a residual yolk, they are comfortable without feed and water for up to two days – providing that temperature inside the chick boxes is kept within their thermoneutral zone. Within this narrow temperature range of 32 - 35 °C, the chick's metabolism is just at maintenance level with minimal heat production and water loss.

If temperature inside the chick boxes rises above this range, the chicks will start to use energy from the yolk sac at a much faster rate, to facilitate panting behaviour in an attempt to maintain optimal body temperature of 40 – 40.5 °C. Proteins used for this purpose are then no longer available for the development of the immune and digestive systems. Panting results in water loss, with the risk of dehydration.

When the temperature at chick level is below the thermoneutral zone, the day old chicks are forced to use their own resources for thermoregulation, rather than for growth and health. In general terms, temperature stress causes discomfort while also suppressing efficient production.

Temperature inside the chick boxes should be kept at thermoneutral zone by balancing the heat produced by the day-old-chicks with the amount of temperature-controlled air flowing through the boxes. The optimal temperature of air circulating inside the truck is dependent on air velocity: the higher the speed of the air, the higher the optimal temperature and vice versa. Well mixed, preconditioned inlet air must flow uniformly through all the boxes, effectively absorbing and dispersing the metabolic heat, moisture and CO₂ produced by the chicks. This should not only be the case in fully loaded trucks, but also in case of partial loads.

Transport conditions are still too often neglected, when in fact they have the potential to significantly affect growth rate, feed conversion, meat yield and the development of the immune system. Optimizing these conditions is highly beneficial for subsequent performance on the farm.

Advice

- Realize the importance of optimising transport conditions from hatchery to farm for subsequent performance. Judging the quality of transport solely by the number of dead chicks on arrival is inadequate.
- Choose reliable chick transport trucks, capable of operating independently from driving speed within the range of prevailing, external climatic conditions in the geographic location of your hatchery and customers.
- Maintain a temperature of 32 – 35 °C inside the chick boxes by optimizing both the temperature of circulating air and its velocity.
- Work quickly during the critical process of loading and unloading when no forced ventilation is present and/or provide sufficient space between individual chick boxes.
- Take the location of temperature loggers into consideration while reviewing the output; avoid direct contact between chicks and sensors!
- Adjust the number of chicks per box if optimal temperature inside the chick boxes cannot be achieved due to limitations in transport equipment.
- Ensure that drivers are well trained and motivated: their professionalism contributes significantly to optimised chick transport.

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Brooding of chicks – a matter of care



Good breeder and hatchery management, together with an optimised incubation process and transport conditions, will deliver a batch of good quality, uniform day old chicks. However this alone is no guarantee of successful post-hatch performance. Of the many factors that have an impact on this, chick reception and brooding management are probably the most decisive. It is difficult to recover from a poor start during the first days, especially when, as is the case for broilers, the production period is short - or in the case of pullets, this will lead to a lack of uniformity.

Preparing the house for the chicks' arrival is an important aspect of brooding management. It is obvious that cleaning and disinfecting the house and equipment thoroughly between flocks is critical: scheduling the maximum number of production cycles a year should not ever compromise attention to proper cleaning and hygiene.

Perhaps not so obvious, is the benefit of allowing sufficient time to warm the house thoroughly, not only to warm the air, but also the floor underneath the litter. The floor should first be fully dried, with floor litter not being spread until a few hours prior to chick arrival, to promote a fast, uniform heat-up.

This attention to temperature in the house is essential, because the chicks' thermoregulatory systems are not yet fully matured. Their body temperatures largely depend on environmental temperature, and if attention is paid to the temperature of the air only, the chicks can still become undercooled if too much heat is transferred to a cold floor through their legs or body or when exposed to draught. Once undercooling has occurred, the

chicks huddle, lie down and remain inactive instead of seeking water and food.

Making the house too warm is not only costly in most instances, but also leads to risk of dehydration as a result of panting, especially in combination with low relative humidity. Again, the chicks will become inactive, resulting in so called "non-starters" and increased first week mortality.

Getting the chicks to drink and eat as soon as possible after arrival is a major target for the successful farm manager. Attention to detail in preparing the house, such as providing extra feed close to the drinkers (e.g. on special paper placed under the drinking nipple lines) or extra drinkers close to the feeders, and adjusting the level and pressure in the water lines, does pay dividends. In combination with a well-illuminated house, the chicks quickly find food and water.

Subsequently, checking the chicks' behaviour regularly - including body temperature and crop fill - allows for the observation of mistakes or oversights during those important first days in the broiler- or rearing-house.

Advice

- Clean and disinfect house and equipment thoroughly between flocks.
- Take sufficient time to warm the floor underneath the litter to 28 – 30 °C/ 82.4 – 86.0 °F prior to chick arrival. Depending on floor characteristics and starting temperature, allow 24 – 48 hours.
- Aim for an air temperature of 33 – 35 °C/ 91.4 – 95.0 °F at chick level depending on size of chicks (smaller chicks require a higher brooding temperature).

- Take chicks out of boxes immediately on arrival in the house, to avoid them becoming overheated.
- Start ventilation in good time to avoid high CO₂-concentration, while preventing draught, at chick level.
- Have fresh, clean water and feed easily accessible well distributed in the entire house.
- Ensure minimum light intensity of 20 Lux; 30–40 lux is recommended.
- Evaluate brooding management by regularly observing chick behaviour and take corrective actions immediately when necessary.
- Use 7-day weight and first week mortality as key indicators for the quality of chick reception and brooding management.

Photo courtesy of Kanters Special Products –
www.kanters.nl

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Preventing Omphalitis to reduce first week mortality



A major cause of increased first week chick mortality is Omphalitis, or navel-yolk sac infection: a hatchery-born disease also known as ‘mushy chick disease’ and ‘navel ill’.

Various bacteria may be involved, such as coliforms, Staphylococcus, Streptococcus and Proteus. Mortality usually begins within 24 hours of the hatch and peaks by 5 - 7 days. Mortality levels of 5 - 10 % are not uncommon, making Omphalitis a significant – and largely preventable – challenge to post hatch performance.

Affected chicks appear depressed with drooping heads. Post mortem examination reveals discolouration around the navel and an inflamed yolk sac with distended blood vessels, together with an offensive odour. The chicks feel ‘mushy’, indicating the presence of subcutaneous oedema.

For Omphalitis to occur, causative bacteria and a route of entry into the yolk sac must be present.

Chicks are not born into a sterile environment. The likelihood of Omphalitis developing is much higher in a batch of eggs that includes bangers, or if the hatcher baskets are not thoroughly cleaned and disinfected prior to transfer. Infection pressures can be effectively reduced by good hygiene practice.

With optimal incubation, chicks will normally hatch with properly healed navels. In some cases, although the navel may be slightly open at hatching, it should close naturally within a couple of hours, while the chicks are drying. In this scenario, the incidence of Omphalitis is minimal.

However if the navel shows any deformity, it creates a point of entry for bacteria. Nutrients in the yolk combined with the body temperature of the chick will produce rapid bacterial multiplication. Maternally derived immunity will not offer sufficient protection against this invasive challenge while the chick’s own immune system is still immature.

There can be several reasons for increased incidence of navel deformity. ‘Black button’ navels are caused by incubation temperatures being set too high, especially during the last days of the cycle. Temperatures that are too low during the final days of incubation will produce poorly closed navels.

Overly high humidity during incubation results in insufficient weight loss. As a result, the residual yolk sac becomes enlarged, which prevents the navel from closing properly. Conversely, when humidity is too low, the yolk sac dehydrates and becomes hard, which can damage sensitive tissue around the navel.

When eggs are stored for prolonged periods prior to incubation, more chicks with black scab navels are observed, indicating unhealed navels at the moment of hatching.

The standard use of antibiotics to prevent omphalitis is not a sustainable solution and should be discouraged.

Advice

- Maintain thorough hygiene, from laying nest to setter, to minimize the incidence of contaminated eggs.
- Avoid eggs becoming wet (e.g. by sweating), as this results in bacterial penetration.
- Clean and disinfect setters and hatcher, trays and baskets, transfer equipment etc. thoroughly after every use.
- Ensure hatcher baskets are completely dry before transfer, to minimize the risk of bacterial penetration through the pores.
- Consider fumigating the hatcher after transfer if a batch of eggs contains ‘bangers’.
- Aim to produce day old chicks without navel deformities by optimising incubation conditions that take breed, maternal age and duration of storage into consideration.
- Target the narrowest hatch window possible – and do not pull chicks while some are still wet, as these are still likely to have slightly unclosed navels.
- Handle chicks under optimal climatic conditions from the moment of pulling until their placement on the farm, to avoid chilling or overheating, as either will be detrimental to the chicks’ immune status and yolk sac resorption.
- Stimulate feed intake as soon as the chicks arrive at the farm, to accelerate yolk sac resorption.

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Dealing with exploders



Hatchery employees, especially when involved in transferring eggs from setter to hatcher, are occasionally confronted with so called 'bangers' or 'exploders'. A loud bang, followed by a very bad smell, are the usual signs. This phenomenon is caused by gas producing bacteria, often *Pseudomonas* spp., inside the egg. Pressure inside such an egg builds up and even a small vibration can be enough to trigger the explosion. During the second half of incubation, this also occurs without human involvement within the setter; empty places in the setter tray and pieces of shell and rotten egg contents on the floor or other eggs are the visible signs. The gas can also press a foamy yellowish substance through the pores of the egg - which makes a potential exploder easy to recognize. Exploding eggs lead to heavy bacterial contamination, putting the hatchery's hygiene status at risk, with negative effects on hatchability, chick quality and subsequent performance.

Eggs are not laid in a sterile environment. Even a visually clean egg has 1,000 to 10,000 bacteria on its surface. This does not naturally cause a problem, as eggs are very well protected against bacterial penetration. However sometimes the egg's defence mechanism is breached, as in the case of eggs produced in wet floor or nest litter. These eggs can later be potential exploders, because directly after laying the cuticle does not offer full protection and bacteria counts are high in these conditions. Moreover the shrinkage of its contents as an egg cools down to environmental temperature will suck bacteria deep into the pores. Water on the shell also facilitates bacterial penetration, which is why it is important to avoid condensation on the egg shell, commonly

called 'sweating', which can occur if cold eggs are suddenly exposed to a higher temperature.

When flocks age, the cuticle becomes thinner and the shells weaker, with an increased risk of hairline cracks, which allows bacteria easy access to the egg's interior. The natural antimicrobial compound lysozyme, together with the bacteria-unfriendly alkaline environment of the albumen, prevents rapid bacterial multiplication. This may even kill all bacteria, if there are not too many. But once the eggs are exposed to incubation temperature, this defence mechanism no longer offers protection. The combination of incubation temperatures and the ready supply of nutrients in the egg will cause the number of bacteria to increase exponentially.

To completely eradicate exploders may not be achievable, but by good management their number can be kept to an acceptable minimum and the negative consequences of an incidental exploder can be controlled.

Advice

- Do not set floor eggs, dirty eggs and eggs with hairline cracks, as these are potential exploders.
- Only set floor or dirty eggs if the disadvantages of setting these eggs are fully understood and accepted, in which case they should be placed on the lowest trays.
- Prevent eggs from sweating and becoming wet.
- Transfer eggs from older flocks after the eggs of young flocks have been transferred, to avoid cross contamination.
- During candling or transfer, remove potential exploders manually and dispose of them either in a bucket with disinfecting fluid or by a vacuum system.
- Clean up the mess after an exploder immediately with a new, clean paper tissue, followed by wiping the area with a cloth soaked in an appropriate disinfectant.
- Consider disinfecting infected batches after transfer with an appropriate disinfectant.
- Plan chick take-off and further handling of infected batches at the end of the day.
- Intensify hygienic procedures, including cleaning and disinfection of the hatchery and all equipment that comes in direct contact with eggs and chicks to reduce the spread of bacteria.

Role of cleaning and disinfection

Because of its central position in the poultry production chain, the commercial hatchery has the power both to stop the spread of pathogens, for example from a Salmonella infected breeder flock, or to intensify a disease challenge, by spreading pathogens to customers or other supplying breeder farms.

Poor hygiene leads to reduced hatchability and poor chick quality, and the risk that farmers will lose confidence as a result of increased first week mortality. It is therefore business-critical that commercial hatcheries take hygiene very seriously.

Even with strict biosecurity measures in place, pathogens will inevitably enter the hatchery. Yet two key actions will prevent these pathogens from undermining good hygiene:

- 1 minimising the movement of pathogens within the hatchery from 'dirty' (e.g. hatcher, chick processing room) to 'clean' areas, by creating hygienic zones, unidirectional product flow, air pressure differences and fluff tunnels
- 2 preventing the further development of pathogens.

We can limit the ability of bacteria and fungi to multiply – for which they require food (proteins, fats, carbohydrates), water, air, and heat, all of which are in plentiful supply in any hatchery environment. Regular cleaning and ensuring that surfaces are dry creates an inhospitable environment for these organisms, which is why smooth surfaces and the avoidance of cracks and crevices are so important. Good cleaning removes up to 85 per cent of micro-organisms – and the remaining 15 per cent can be eradicated by proper disinfection.

Important considerations in the choice of chemicals for cleaning and disinfection are:

- pH values: alkaline soap removes organic dirt (protein, fat) – acid soap removes mineral deposits (such as calcium). Depending on water hardness, the occasional use of acid soap will help maintain smooth surfaces.
- Compatibility: check that the soap does not render the disinfectant ineffective.
- Range of efficacy: broad spectrum disinfectants provide efficacy against a variety of micro-organisms, e.g. Gram-positive and Gram-negative bacteria as well as different viruses and fungi, versus narrow range disinfectant, eg. effective against Gram-negative bacteria only.
- Residual activity, to avoid recontamination.
- Method of application: for example, room disinfection requires gas or fog, while setter disinfection is best achieved with spray.
- Safety for hatchery staff, equipment (corrosiveness) and the environment.
- Pricing: cheaper is not necessarily better. Also consider the concentration required while comparing products.

Commercial disinfectants often contain more than one active ingredient, to complement each other in the fight against a wide variety of pathogens, together with buffering agents, wetting agents, sequestering agents etc. to ensure their efficacy in contact with organic matter, in cold water, in low and high pH and to increase the shelf life.

Advice

- Specify a mandatory schedule of cleaning and disinfection for all rooms, setters and hatcher, equipment, trays, baskets, trolleys.
- Train staff fully, making sure they understand the importance of cleaning and disinfecting all areas properly.
- Always clean thoroughly to remove the majority of micro-organisms before disinfection: remember that 'dirt' inactivates disinfectant. The following routine is recommended:
 - 1 Remove loose dirt.
 - 2 Cover whole area with soap and soak for about 15 minutes.
 - 3 Remove soap together with suspended 'dirt'.
 - 4 Allow to dry properly, as any remaining water will over-dilute disinfectant.
 - 5 Apply disinfectant according to the manufacturer's instructions.
- Discuss your requirements with your supplier to identify the right products for cleaning (soap) and disinfection (disinfectant).
- Take agar cultures or swabs regularly, to monitor the efficacy of cleaning and disinfection procedures.

How effective is your cleaning programme

Cleaning and disinfection are fundamental to effective hygiene in the hatchery. Cleaning can remove up to 85 per cent of micro-organisms, preventing their development by removing their food sources, or 'dirt'. Any remaining micro-organisms can then be eradicated by disinfection.

However, a cleaning and disinfection programme is like fighting an invisible enemy and to evaluate its efficacy, that enemy can be made visible by monitoring.

Three options for effectively monitoring hatchery hygiene are:

1 Visual inspection

Regularly take a critical look at levels of cleanliness throughout the hatchery and its equipment. Use a checklist, on which dirty spots (such as remains of broken eggs, fluff) can be indicated and recorded. Pay special attention to hard-to-reach areas, like backside cooling coils, door rubbers, ventilation pipes and the suction heads of the transfer machine. When dirt is visible to the naked eye, there will certainly be many micro-organisms present.

2 Agar cultures for non-specific bacteria

Make the enemy visible with a non-specific bacteria count. When compared with a reference (see example in table), this will illustrate the efficacy of your cleaning and disinfection programme. Remember that pathogenic bacteria and other micro-organisms are likely to co-exist alongside non-specific bacteria, and some fungi can also be revealed by this procedure.

Methods for inspecting flat surfaces (e.g. walls, ceilings) include:

- Swab and streak procedure: rub a sterile swab, moistened in a sterile

solution or a manufactured sterile culturette, over a 2.5 - 5.0 cm area of sample surface. Gently streak the used swab over the surface of an agar plate several times, in a zig-zag fashion.

- Rodac plate procedure: Rodac plates are pre-filled with agar gel, which is slightly higher than the edge of the plate, so that direct contact can be made with the surface to be sampled. Remove the cover of the plate, press the agar gently onto the surface to be monitored (do not move the plate while contact is made), then replace the cover, taking care not to touch the agar.

Whether you use swabs or Rodac plates:

- Keep one agar plate unopened as a 'negative sample', to test the sterility of the plates and act as a 'control'.
- Clearly mark where each sample was collected on the outside base of each plate. Predefine the number of samples per room – and test a variety of locations within each room/area (e.g. door handle, candling table, hatching egg).
- Store collected samples and your 'negative' sample upside down at 37 °C - 37.5 °C in a laboratory incubator or setter, taking care to place the plates in a plastic bag and set them down where they will not be disturbed. Agar contains nutrients that bacteria thrive upon. A single bacterium – and to a lesser extent, a fungal spore – will multiply under these conditions, to become visible as a colony.

After 24 - 48 hours, count and record the cultures. The number of colonies present indicates the hygienic state of the surface sampled. The evaluation of these counts should be based on the hatchery's own criteria, or by the terms of a national or integration-wide quality programme. An example is given in the table.

Based on Rodac plates with a diameter of 5,5 cm; Number of samples and locations are specified.

Colonies/ Plate	Score	Average hatchery score	Rating
No colonies	0	0.0 - 0.5	Excellent
1 - 40	1	0.6 - 1.0	Good
41 - 120	2	1.1 - 1.5	Reasonable
121 - 400	3	1.6 - 2.0	Moderate
> 400	4	2.1 - 2.5	Bad
Uncountable	5	> 2.6	Very bad

Evaluation of bacterial counts according to Dutch standards (1999 Poultry Farming Hygiene Regulations).

3 Specific bacterial and fungal monitoring

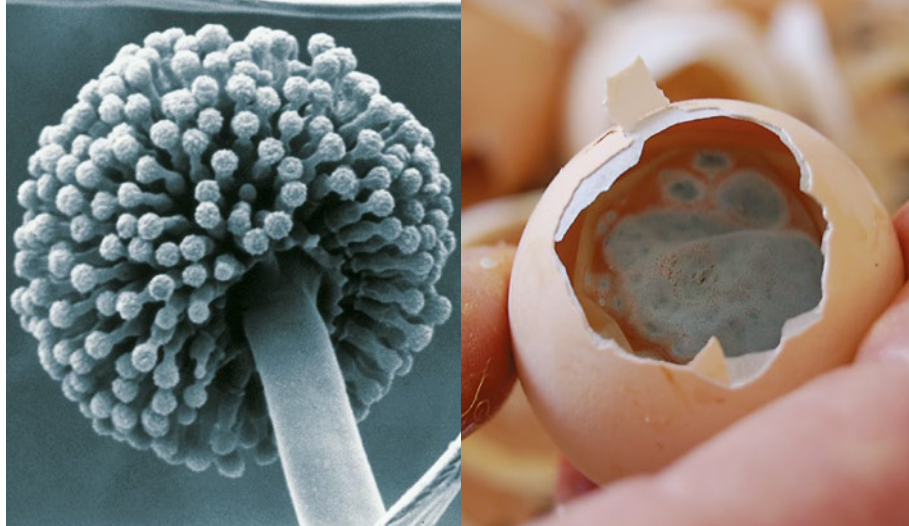
To test for particular bacteria and fungi, specific plates contain a selective agar, formulated specifically to encourage growth or colonisation by the bacterium/fungi being investigated. Fluff, chick paper and other hatchery materials may also be prepared for monitoring in this way. For specific monitoring, it is often advisable to contact a specialised laboratory for sampling and/or an accurate interpretation of results.

Advice

- Discuss the results from this type of monitoring programme with staff responsible for cleaning and disinfection and/or with your supplier of detergents and disinfectants.
- Change procedures and/or consider a change of the cleaning and disinfection products being used if the results are unsatisfactory.
- Maintain records of all results, so that any changes occurring over time can be observed in the different areas monitored.
- Compare the results of hatchery hygiene monitoring with hatchability and liveability data.

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Keeping the hatchery free of Aspergillus



Aspergillosis is a fungal infection of the respiratory tract in young birds, also commonly known as 'brooder pneumonia'. In infected birds, the air sacs and lungs show white to yellow spots or lesions. Infected birds gasp for air and have accelerated breathing. Aspergillosis can also result in severe eye (and even brain) infection, which can appear as a yellow cheesy pellet beneath the eyelid. Increased mortality rates of 5 to 50 % may occur within 21 days after the placement of diseased birds.

Day-old chicks with signs of Aspergillosis are infected by the spores of Aspergillus species, among which *Aspergillus fumigatus* is the most common. The spores of the fungus *Aspergillus* are like small, dry seeds that can easily be spread by draught or the wind. The spores are found in low numbers throughout the whole environment. *Aspergillus* spores survive and grow in a wide range of conditions, but especially on organic matter, like egg yolk, cardboard boxes and wood. Growth in the spores is initiated by conditions of high humidity and temperature (37 - 45 °C). Cycles of high and low humidity optimise the growth of the fungus (mycelium) and the spread of its spores. The hatchery therefore provides optimum environmental conditions for *Aspergillus* to thrive.

Aspergillus spores can enter the hatchery either directly via the eggs, or via incoming air.

When the hatchery environment is contaminated by a high level of *Aspergillus*, the spores can easily enter the air handling unit and ventilation system. The climate, temperature and humidity in ventilation ducts is ideal for the propagation of *Aspergillus*, especially when organic matter (debris) has accumulated.

The main route into the hatchery for *Aspergillus* spores however, is usually via contaminated eggs. *Aspergillus* spores attached to the shell find their way into the albumen and yolk via hairlines or cracks in the shell. The yolk of the egg is an ideal substrate for the growth of *Aspergillus* and once the spores have entered the eggs, the way to the hatchery is open.

The nests also contain several sources of *Aspergillus*, including bedding, manure and feed. The nest eggs therefore become contaminated by contact with *Aspergillus* spores from these sources. Floor eggs also, of course, have a high risk of being heavily contaminated, when the spores enter the egg via hairline and other cracks.

Initially, infection by *Aspergillus* will be found during the routine analysis of unhatched eggs. Infected eggs show a visible mould on the membrane in the air cell (see picture). The risk of a serious bloom of *Aspergillus* is high when 0.5 % of the hatching eggs show clear infection with a visible growth of the fungus. Also, the frequency of embryos dying at about day 16 is higher than expected.

Advice A

Prevention is of course the first line of action. To prevent *Aspergillus* infection in the hatchery, the following measures are recommended:

- Use Hatchery Recording Forms to ensure that the origin of eggs is traceable.
- Do not incubate floor eggs.
- Do not incubate cracked eggs or eggs with hairlines.
- Avoid wooden walls, ceilings or surfaces in the hatchery, since *Aspergillus* thrives well on wooden surfaces.

- Analyse unhatched eggs on a regular basis – and if infected eggs are found, take measures to trace the sources of *Aspergillus* (see B).
- Ensure your hatchery sanitation programme is fully maintained. If moulds are found, take immediate measures to clean the hatchery (see B).
- Ensure that your hatchery sanitation programme includes the cleaning and disinfection of ventilation ducts.
- Remember that hatchery equipment must be free of all organic matter before disinfection. It makes no sense to disinfect equipment, trays or boxes when debris remains stuck to the surfaces.

Advice B

If *Aspergillus* has been found in the hatchery the following is recommended:

- Thoroughly clean and disinfect the hatchery - including ventilation ducts – with an effective fungicide. If necessary, ask your supplier for advice on the most effective solution.
- Apply the fungicide at a regular interval because the spores of *Aspergillus* species are highly resistant to fungicides. Any surviving spores will develop into a mature spore-producing mould, thus the fungicide should be applied before this stage of development is reached.
- Trace and eliminate the source of the *Aspergillus* spores, the main source of which is usually found at the breeder farm in the (wooden) nestboxes, litter, cardboard boxes and wooden walls or ceilings.

Photo courtesy of Janssen Animal Health

Effective rodent control on breeder farm and hatchery

Rodents (rats and mice) are documented carriers of *Salmonella spp.* and therefore present a serious concern for public health. A review of Meerburg et al. (2007) showed infection rates in rodent populations ranging from 0 - 77 per cent.

An entire breeder flock or hatchery can be contaminated by the presence of a single infected rodent, thus posing a risk to the rest of the food chain. Besides the danger of infection, rodents cause damage to buildings, electrical lines and water pipes, thereby affecting production and profitability. For these reasons, an effective rodent control program is essential.

Rodent control begins with getting to know your enemy. Rats are intelligent, social animals that live in colonies of several hundred individuals. These rodents have a strong tendency to burrow, especially into soil or under secure coverings such as piles of stones or rubbish – and they prefer to move under cover of darkness. They have a range of 100 meters plus – and they breed quickly. A healthy female can easily produce 5 litters per year, each of 8 - 10 pups, with offspring attaining sexual maturity in 8 - 12 weeks.

As many as one third of the females in a population may be pregnant at any one time. And because of their agility and their ability to squeeze through small openings, it is very difficult to keep them out of poultry houses, feed stores and hatcheries. The range of mice is much smaller (5 meters) than for rats. However as mice reach sexual maturity 42 days after birth, populations grow much faster than those of rats. Being so small they are very easily carried, unnoticed, in for example egg boxes. They can enter a building through gaps as small as 6 mm (the diameter of a pencil!).

Rodent infestation can quickly take hold without even seeing a single animal, because their nocturnal habits tend to keep them away from human eyes. If a single rat is seen during daytime, there is already a sizeable infestation. To control rodents requires constant attention – and it is common for breeder farms and hatcheries, especially in the case of larger operations, to place responsibility for rodent control in the hands of a specialized pest control company.

An effective rodent control program involves three areas of activity:

- 1 prevention – do not attract rodents.
- 2 monitoring – looking for signs of rodent presence (seeing no rodents does not mean they are not there!).
- 3 control – the use of rodenticides to eliminate the pests and prevent populations from thriving.

Advice

- Keep the area around the breeder houses and hatchery clean and tidy. Avoid decorative shrubs within 1 meter of buildings and cut grass regularly.
- Do not attract rodents with food sources, such as chicken feed, hatchery waste and leftovers from canteens.
- Make the houses rodent proof: cover ventilation openings with wire netting and ensure there are no openings or gaps under doors.
- Monitor at weekly intervals for signs of rodents, such as: runs, smears, droppings, urine odour, gnawings, foot prints, holes and burrows and uptake from bait boxes.
- Eliminate rodents by using an effective rodenticide mixed with an attractive bait.
- Place sufficient purpose-designed bait boxes at carefully chosen points where rodents pass or gain access regularly.
- Monitor uptake from bait boxes and add or refresh rodenticide as required, to avoid resistance or 'bait shyness'. With preferred 'slow-kill poisons', rodents must ingest some of the poison daily for several days.
- Change the rodenticide at regular intervals to avoid resistance and 'bait shyness'.
- Consider using a specialised company to carry out the rodent control program. An effective rodent control program requires knowledge, experience and consistency.

Selecting a hatchery location

Having made the decision to build a hatchery, finding the right location is a critical first step. Not every piece of land is suitable as a hatchery site - and finding a good location that is fit for the purpose deserves some time and proper investigation, in order to give the hatchery a good start.

There are five key factors, namely District Ordinance, Environment, Infrastructure, Altitude and Soil, which should be carefully reviewed to determine whether a location is suitable or not.

Consider district ordinance and any permits that may be required to begin constructing the hatchery. As an industrial building, there may be concerns for example over pollution or other environmental impacts, which could result in restrictions at the selected location. Are there any development plans for the future of the area where the hatchery is intended? Checking these aspects of your hatchery plan before investment begins is always advisable.

To maintain high level biosecurity, the hatchery should be located at least one to three kilometers from any other poultry and livestock farms. Prevailing wind direction should be monitored, especially in relation to the hatchery's air inlet and exhaust points, to avoid introducing dust and contaminants from the environment.

A good infrastructure foresees the hatchery's accessibility, energy and data communication needs, both for start-up and in the future. Easy access is an absolute necessity for the modern hatchery. A badly surfaced road will cause vibration to the eggs on the truck, which may reduce egg quality. As importantly, the location of

the hatchery in relation to its farm customers can significantly improve logistics and help to reduce costs.

The hatchery needs energy to operate and, depending on its size, a certain amount of electrical, cooling and heating capacity. These can be provided by a variety of energy resources. The primary supply may be mains power from the local power grid and a nearby lake or river, for example, may provide an excellent source of cooling. For all the hatchery's different energy needs, it is critical that an uninterrupted supply is available - and wise to ensure that back-up installations are in place.

Data communication is fundamental to any modern business. Good access to the internet will enable machinery software to be updated and support functions to be accessed remotely, as well as enabling anywhere, anytime logins, to check on operations.

Hatchability and chick quality are affected by altitude. Barometric pressure declines with altitude, as does the partial pressure of oxygen and absolute humidity. Fresh ventilating air will tend to be colder and drier at altitude than at sea level. These affects can be minimized, depending on the altitude at which the hatching eggs are

produced and the corresponding adjustments made to the incubation programme.

Finally, the properties of soil types do differ and may, for example, be more prone to expansion or shifting than other types. If the ground at the new hatchery site is unstable, this could compromise the hatchery structure, causing cracks in the walls or problems at foundation level. Soil testing will determine the type and depth of foundations required for your hatchery, enabling an accurate cost projection for the type of groundwork necessary.

Advice

- Review any planning consents or restrictions and any future development plans for the district in which the hatchery will be located.
- Monitor and maintain a high level of biosecurity for the area surrounding the hatchery, to minimize or prevent any risk of contamination.
- Ensure that energy supplies are stable and reliable, to protect the hatchery against failures or damage to machinery.
- Consult a specialist for advice and guidance in relation to the effects of altitude on the incubation programme.
- Probe the location's geographical features and soil properties, to inform the development of the hatchery's groundwork.

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Optimising hatchery design for peak performance



Having chosen a green field site for the new hatchery, it is important first to consider the lay-out of the facility carefully, followed by producing an engineering plan of drains, piping, ducting and cabling.

Good design is crucial to cost-effective hatchery operation – and should avoid long walking distances anywhere on the site, to minimize the use of internal transport. To prevent cross-contamination, the plan should incorporate a uni-directional flow of people, eggs, air, trays, baskets and trolleys: ‘clean’ should never meet ‘dirty’.

A well designed hatchery lay-out will set out five distinct areas for the eggs, incubation, newly hatched chicks, technical operations and personnel.

In the egg area, will the eggs arrive on farm trolleys, paper/plastic trays or egg boxes – and in what quantities? How long will eggs be stored – and will they require different temperatures? Will grading and selection take place at the hatchery or at the farm – and is egg handling automated or manual? Are eggs fumigated on arrival, or before setting? Should there be a room for storing discarded hatching eggs and are rooms for washing and storing trays or trolleys required?

The incubation area will be subdivided into setter room, candling and transfer room and hatcher room. Depending on how many setters are installed, there will be one or more rooms to maintain a reasonable walking distance along the length of each row of setters. The size of the transfer room depends on the automation equipment being used and on the number of eggs being processed. Also consider how candling waste will be dealt

with. Finally in this area, the number of hatchers in each hatcher room should allow efficient ‘all in-all out’ operation – and therefore depends on the setters’ capacity and the number of hatches produced weekly.

The chick area may need additional space for sexing and vaccination equipment. The size of the handling room also depends on the level of automation. Holding room dimensions should be based on the number of chicks stored and whether or not males and females are separated. In harsh climatic conditions, it makes sense to plan for loading onto trucks inside the building. And a soaking room for cleaning dirty chick boxes returned from the farm is also advised. Ideally, this is located adjacent to the storage area for empty chick boxes. Hatchery waste, e.g. empty shells, unhatched eggs and dead chicks, can be removed from the hatchery by a macerator and screw conveyor, situated near an outside wall. A vacuum waste system offers more flexibility and improved hygiene.

Ideally the technical area is divided into separate rooms for electrical installation, hot water installation and ventilation. Technical operations should also be located on an outside wall, so that engineers need not enter the hatchery unnecessarily. Every hatchery should also have a small workshop for repairs and storing spare parts.

Personnel require sufficient male and female showers and changing rooms to comfortably accommodate the number of people employed. Similarly, egg handling and chick handling personnel should ideally have separate canteens.

A laboratory and an office for the hatchery manager, perhaps with additional offices for sales, transport and administration, are also advised.

Advice

- Consult a specialist for advice and guidance in designing the hatchery lay-out: someone qualified and experienced, who will consider the various options available to you.
- Treat the prevention of cross-contamination as a major factor when designing the hatchery lay-out.
- Avoid very long rooms, to minimize the use of internal transport.
- Situate staff areas, particularly comfort areas, on outside walls for natural light whenever possible.
- Design with future expansion in mind, such that, for example, the addition of setter and hatcher rooms allows egg and chick areas to remain in their original location.

Modernizing or Expanding a Hatchery

When building a new hatchery, we have the freedom to plan exactly what we need, where we need it, right down to laying the groundwork for future expansion.

Modernizing or expanding an existing hatchery poses more of a challenge. When installing or modernizing incubators or automation equipment, limitations can come from standing structures (walls, columns), piping, ducting, etc., which cannot always be moved or removed as required. A review of existing facilities with the architect or building contractor, including planning permissions where applicable, should be the first step in any decision to rebuild or expand an existing hatchery.

Invariably there are choices that have to be made. Is it viable to achieve 'optimal' routing by demolishing and/or rebuilding walls? Or does a 'compromised' routing work better, while retaining as many existing walls as possible? What type of materials will be used to rebuild the hatchery? Will modernization or expansion be in an existing part of the hatchery, or require additional building? And will the project be well-served by extending existing systems and infrastructure – or will it require additional energy, air and water supplies?

The infrastructure of the hatchery should be considered. Involve plumbing and electrical contractors, for example, in reviewing hatchery service installations – and the consequences of modernization or expansion. Piping and ducting are easier to replace than standing structures – but consider that existing services must keep running alongside any new installations during rebuild or construction.

With a good review of the existing hatchery and a thorough understanding of any restrictions, designing the new hatchery lay-out can begin.

Care in scheduling building phases, materials and contractors will help keep budgets and timescales on track, as will clear, responsive communication between all the parties involved. With everyone's involvement, it's a good idea to document the work that needs to be done, who will do it – and when it should be completed.

Advice

- Review any permits, applications and licenses that are required to modernize or expand the hatchery.
- Check that there is sufficient capacity in existing energy supplies for modernized/expanded hatchery systems – or make alternative plans for energy supplies.
- Separate construction area/s as much as possible from existing hatchery operations.
- Prepare the logistics of the project so that suppliers and contractors spend as little time as possible inside the operating hatchery.
- Consider building in separate phases when very large changes are necessary.
- Keep one master planning document on record, so that everyone, including external contractors, know exactly what needs to be done and by when.

Future-focused hatchery construction



Sustainability is an important feature of contemporary building design, often reflected in building regulations – and very achievable, given the many, varied material, design, energy and equipment solutions that are currently available.

A hatchery building is made up of various construction layers, and therefore likely to use a combination of materials in the bearing structure, roof covering and façade cladding.

Selecting building materials

Early in the design process, materials are selected for each of these layers, based on their design, operating life, strength, appearance, fire safety, sustainability, speed of construction and cost.

Bearing Structure

Various materials are suitable for the bearing structure. These include concrete, steel, wood and mixed construction materials. Steel is often chosen because it is sustainable and strong yet light-weight, and it offers variety and rapid construction speeds.

Portal truss frames (with hinged column base joints and frameworks with hinged or wedged column bases) are highly recommended for the bearing structure. Portal frames possess adequate stability, requiring only perpendicular connections to deliver excellent stability and structural integrity. Where a larger span is required, truss beams are a good solution.

Roof Covering

Minimal energy loss, to retain constant temperature and maximum climate control inside the building, is the aim when choosing a roof covering. Insulation, proper ventilation and the erection of the roof structure are important considerations when deciding on roofing materials, as is tolerance to natural, external stresses, such as snow, rain or wind.

Options for the roof covering include profile sheets with separate insulation sheets, steel roofing sheets with anti-condensation lining, corrugated fibre cement sheets, uninsulated roof panels and sandwich panels.

Sandwich panels and profile sheeting with separate insulation are well suited for this purpose. These are fixed to the outside of the bearing structure, with the insulation sheets installed on the inside.

Façade Cladding

Insulation and aesthetics are the two main considerations when choosing a façade cladding system. While masonry, prefabricated concrete panels and steel sheeting are often popular choices, steel cladding (sandwich panels) often yields the best results.

Covering façades and roofs with the same panel types is not advised, as differences in slope and load mean differing requirements in detailing, fastening and joins.

Ideally, façade panels are installed on the inside of the bearing structure, for ease of cleaning and hygiene. Take care to check the join between the façade cladding and the floor, to prevent the accumulation of dirt and water. Floor skirting may provide a good solution if this is a problem.

Sandwich panels are often recommended for hatchery construction because they offer many advantages, including:

- Core materials and skins work together structurally
- Sandwich panels are available in all forms and types of material
- Prefabricated forms deliver short construction times and reduce costs
- Both sides are finished
- Outstanding structural characteristics
- Can be assembled and disassembled in virtually all weather conditions
- Hidden fastenings can be used to ensure that screw heads are invisible
- Inherent rigidity means fewer fastening points
- Extremely high thermal insulation
- Lightweight
- Large spans require minimal backing structure
- Fire-resistant filling

Advice

- Aim for simple structural design for the main bearing structure, with a limited number of components and joins.
- Expect good information on the choice of materials from the architect / construction company.
- Consider delivery times when choosing materials. Sandwich panels are manufactured to the required specification.
- Clad roofs and façades with different panels: using the same materials for both is not advised.
- Investigate the subsidies that may be available when using sustainable materials.

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Hatchery flooring and drainage: boosting performance at ground level



The quality and construction of hatchery flooring can contribute significantly to operational productivity and cost-efficiency.

Load bearing capacity is established from a concrete base layer, reinforced with steel or concrete, depending on the strength and stability of the natural substrate. Building then continues upwards, starting with a sub-base of compacted granular material or lean-mix concrete, followed by a damp-proof layer, insulation, reinforced concrete and a water-tight top finish.

Completed, the floor is flat and level, highly resistant to pressure washing and chemicals, and strong enough to withstand both concentrated and moving (wheeled) loads. A loaded 115k egg capacity incubator weighs approx. 450kg/m², while trolleys filled with hatching eggs, repeatedly travelling the same path on typically polyamide or vulcanized rubber wheels, generate very high contact pressures of $\pm 5\text{--}15\text{N/mm}^2$.

An hygienic, easy to clean, anti-skid surface can be achieved with a monolithic (poured as a single slab) build-up, mechanically sanding then plastering the surface, which is finally sprinkled with a wear resistant additive during drying.

Alternatively, and more commonly in modern hatcheries, a cement-bonded base with synthetic finishing layers delivers better performance and durability. Combined with Microban®, the synthetic resin surface also provides continuous antimicrobial protection.

Seamless, mechanical installation creates a hygienic, extremely hardwearing finish, with the resin layering process delivering improved chemical and thermal resistance, durability and easy maintenance over time. Resin screeds also create a good seal with walls and can be installed with skirting, for improved cleaning. This type of flooring is fully chemically bonded to the concrete substrate, which prevents the collection of dirt or bacterial contamination in joints or hollows under the finished floor.

High-speed installation produces greater efficiency in the building schedule, ultimately reducing total project lead-times.

Drainage is factored into the build of the floor, with a slope to remove wastewater and promote good drainage.

Drains and gulleys are situated in processing areas and passages, where easy access for regular cleaning reduces the level and subsequent risk of contamination. With a smooth, durable surface, stainless (AISI 304) drains are easily cleaned and strong enough to support the weight of moving loads. Wide, gridded drains are recommended for areas such as the hatcher room, washing and chick handling areas, where a larger capacity is more efficient for the removal of egg shell and other detritus during washdowns. Narrow drains are suitable in hallways and less polluted areas.

Advice

Floors:

- Consult a concrete specialist, to specify the floor correctly for purpose, load and long-life.
- Prevent cracking by reinforcing the concrete with steel.
- Level the floors under setters and hatchers to a grade of 1 %, or within 2mm per 1000mm, and flat to within 3mm per 1000mm (Class 2 conform NEN-2747).
- Place floor joints in the center of panel walls, not under hatchery equipment, whenever possible.
- Avoid the use of glazed floor tiles, which create a slip-hazard when wet and are prone to cracking and breaking, which creates dirt-traps.
- Select an installation supplier who will honour a guarantee on your floors.
- Consider using Microban® in the finishing layer, for continuous antimicrobial protection.

Drains:

- Locate drains close to setters and hatchers, to remove wastewater from washing between cycles and help to dry these areas thoroughly and quickly.
- Install floor drains with the recommended slope or grade of 1 %.
- Select the pitch or mesh rating for drain grills and gulley covers such that waste water and small eggshell particles are washed away effectively, without impeding or disrupting the travel of trolleys carrying eggs.
- Build-in floor drains to a depth of c.160mm, with suitable piping of 110/125mm.
- Install a waste trap at the end of each drain, to prevent fluff and solid waste from entering the drain piping system.

Ergonomic benefits in the hatchery

The hatchery is generally regarded as a safe place to work, reporting very few incidents when compared with other industries. In practice, that does not mean that working in the hatchery is entirely without risk. A proper regard for Health and Safety in the hatchery requires great care in managing factors such as dust, noise, climate and the use of chemicals, for example.

However incidents among hatchery personnel tend to arise from more subtle causes related to repetition, force and posture: factors with effects that often develop over time. This article focuses on these areas and the positive impact that results from the use of ergonomics in industrial design.

Muscular pain affecting the wrists, shoulders, neck and back are potential challenges for hatchery employees, with three major factors that may contribute to such complaints in this environment: (1) highly repetitive tasks: repeating the same motions over and over again, quickly and with little variation, eg. when manually transferring hatching eggs from pulp trays onto setter trays; (2) carrying heavy weights and (3) working in suboptimal positions, for example with the hands raised above shoulder level for prolonged periods or repeatedly, such as is required when manually loading a setter trolley.

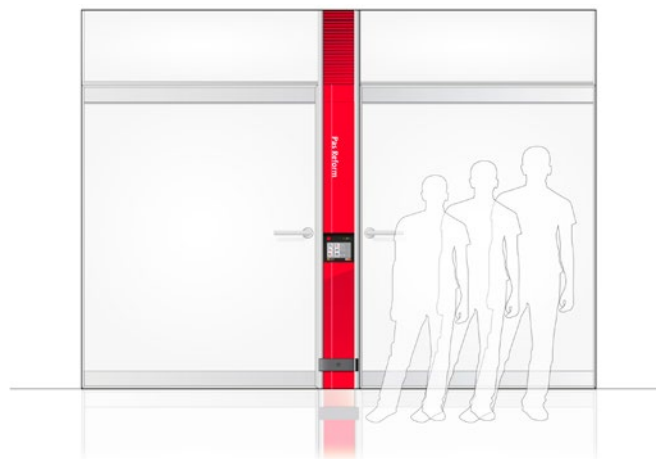
Factors such as repetition, force and posture can be largely controlled and overcome by improved working practices. But in the hatchery environment, the use of ergonomics in the design of incubators, hatchery automation and climate control systems is also known to substantially benefit both the hatchery and its personnel.

By opting for ergonomically designed equipment, the hatchery demonstrates its care for personnel over the long term. Thoughtful engineering translates into a safe, efficient environment that, with simple-to-use operator interfaces, also reduces the risk and cost of mistakes.

The aim of ergonomics is to control risk factors associated with an individual's comfort, efficiency, safety and productivity, through improved working practices and optimised industrial design in the workplace. By delivering better performance and job satisfaction, sound ergonomic sense also makes good economic sense.

Advice

- Reduce the frequency and duration of repetitive motions, by implementing job rotation to move hatchery employees around a number of different tasks. To avoid any risk of cross-contamination, personnel should only be rotated within the same area of operation within a single shift.
- Deploy ergonomic lifting and transport tools such as scissor lifts, setter trolley loaders, stackers, destackers, hand dollies, carts and forklifts, to reduce the load.
- Objects that must be lifted manually should be placed at waist level.
- Make the operation of incubators, hatchery automation and climate control systems simple, safe and easily accessible to operators of all skill levels; ensure that any software used is suitable for the personnel using it, avoiding information overload.
- Consider the viewing angle of a machine's user interface and use large, high-contrast, high resolutions colour screens with clear icons that allow for optimised viewing and configuration.
- Make use of highly manoeuvrable trolleys with swivel wheels and ergonomically designed handlebars for ease in loading and unloading incubators. Handlebars should ideally be waist height.
- Opt for lightweight setter trays and hatcher baskets, with a smooth finish and lateral hand holds for maximum grip and comfortable handling.



Modern hatchery equipment manufacturers place great importance on ergonomics during product design and development.

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Weighing the benefits of automation in the hatchery



A common rationale for investing in hatchery automation has traditionally been to reduce labour costs or to overcome the challenge of recruiting for monotonous, relatively strenuous work and long working days.

Yet the use of hatchery automation systems is growing rapidly in modern hatcheries - and not only in countries with relatively high labour costs. Hatcheries in low labour cost regions are also capitalising on the improved accuracy, workflow, overall quality and financial benefits that automation delivers.

There are many good reasons to introduce automated processes in the hatchery, and a range of (semi) automatic equipment solutions are available. These solutions reflect the variety of opportunities that exist in hatcheries of varying sizes, process plans and outputs, to improve productivity and performance.

In the egg traying room, for example, eggs are transferred from small pulp or plastic trays to setter trays. Careful handling of the eggs, to avoid hairline cracks and ensure that the eggs are placed sharp-end down, is essential for good hatchery results. Well designed and adjusted automation achieves greater accuracy and consistency than manual egg handling. And when we consider that in an ordinary hatchery transferring 230,000 eggs/week, a one per cent increase in hatchability represents an additional 100,000 day-old chicks/year, it makes sense to weigh the cost of a manual v. automated process!

Care in handling during egg transfer is also critical. Here this is more challenging, because the egg shells are more fragile, due to calcium absorption by the embryo

for bone development. Automated candling and egg removal save considerable labour, depending on the system chosen – and deliver better results, especially where the percentage of clears is higher than 10 - 15 %. Automation also allows for more effective waste separation: especially beneficial if, for example, clear eggs are being brought to value, e.g. as egg powder for use in pet food.

Inside the chick handling room, the equipment used depends largely on the size, type and local work force situation of the hatchery. The priority is to ensure that chicks leave the hatchery as fast as possible, in premium condition. If labour saving is the main priority, stackers/destackers, connecting conveyor lines, automated basket storage and automated chick separation may be a logical choice. In weighing up the options, consider also the cost of time needed, for cleaning, disinfecting and accurately grading chicks. Further automation in chick handling may include chick counters and boxing systems, sexing tables, vaccination tables and spraying systems.

Hygiene is another area of hatchery management well-served by automation. A large range of automatic washing equipment is available for cleaning setter trays, hatcher and chick boxes and various trolleys. Systems are also available for dealing with hatchery waste, such as macerators and vacuum waste lines.

Hatchery automation systems are becoming an essential factor in the operation of the modern hatchery. And cost rapidly becomes an investment, when the main benefits include a higher number of uniform, high quality chicks, accurate process planning and timely delivery.

Advice

- Consult a specialist when planning hatchery automation systems, as many factors need to be considered and several options are available.
- Decide what has the highest priority in making the choice for which processes should be automated; labour saving or quality improvement.
- Invest first in egg handling automation for setting and transfer if the focus is on quality improvement, as this is where relevant benefits will be gained – mainly by reducing the incidence of hairline cracks and a greater accuracy in point-setting.
- If the aim is to save on labour, invest first in internal flow automation systems – from stackers/destackers, conveyor systems and automated chick separation, to fully automated basket storage.

The relevance of Hatchery Climate Control

While optimising climate inside the incubator best supports the needs of growing embryos, accurate climate control elsewhere in the hatchery also makes an important contribution to overall efficiency.

Growing embryos use oxygen and produce carbon dioxide and water vapour during incubation, thus the air within the incubator needs to be refreshed regularly. However to maintain truly efficient climate control, there are other important factors to consider, including temperature and relative humidity in the various rooms of the hatchery, the avoidance of airborne cross-contamination and energy saving.

Homogeneous incubation temperature is best achieved when the machines operate in an area where temperature and humidity are constantly maintained. Maximum room temperature is reduced when the incubator depends partially on air cooling – and in this case, a greater volume of air will be required than when using a water-cooled system, to cater for both the oxygen needs of the embryos and the cooling requirement of the incubators.

Similarly, it is useful to humidify inlet air. This avoids the creation of ‘cold spots’, which arise with the constant operation of a humidifier in the incubator: particularly relevant for hatcheries in dry and/or cold regions. Conversely, hatcheries in hot, humid countries can benefit from dehumidifying inlet air, so avoiding overly high humidity in the setter – which results in insufficient weight loss by the hatching eggs during incubation.

Air transport by natural ventilation substantially limits the hatchery’s control of temperature and humidity. An air handling unit (AHU) enables inlet air to be conditioned and regulated, based on the needs of the embryos. This is achieved by controlling the output of the AHU according to the pressure required in various rooms. With pressure differences set such that air flows from ‘clean’ to ‘dirty’ areas, cross-contamination is prevented.

By reducing supply air volume to the lowest necessary levels and eliminating unnecessary heating (including humidifying) or cooling (including de-humidifying), energy savings will be realised. Fans operating at variable speeds are more energy efficient for controlling pressure in the hatchery than recirculation – and selecting setter/hatcher room temperature in relation to external, local climate can also have a positive impact on energy consumption.

Advice

- Consult a specialist when designing the hatchery’s climate control system, as many factors need to be considered and there may be several options available.
- Ensure sufficient air supply to the various rooms in the hatchery.
- Precondition air in terms of temperature and relative humidity to meet the climate requirements in the room.
- Avoid high (>25 °C) room temperatures in a cold climate.
- Use variable air supply with frequency drive instead of recirculation.
- Always maintain the highest air pressure in the setter room compared to other areas, to avoid cross-contamination.
- Avoid using air ducts to extract used air. These are difficult to clean and encourage an accumulation of pathogens (eg. Aspergillus).
- Maintain the AHU, regularly replacing dust filters and checking the V-belts.
- Monitor climatic conditions (temperature, relative humidity, CO₂) in relation to the specified requirements for all hatchery rooms every 14 days .

Hatchery management training



At Pas Reform, we recognise the importance of people to the success of any hatchery operation.

For that reason, we have developed a practical one week training program for people involved in the day-to-day management of the hatchery. As an interactive, 'hands-on' program, participants have the opportunity not only to learn from Pas Reform Academy's Trainers – but also by sharing the experiences of other professional hatchery personnel.

The one week Hatchery Management Training program has a thematic approach that focuses on teaching participants about the latest new developments in incubation technology. Training is suitable for experienced hatchery managers as well as those new to the field. It is not essential that participants have experience in working with Pas Reform incubators.

Training Program Content

The course begins with an exploration of factors affecting hatching egg quality, with particular attention given to egg storage.

A detailed presentation and practical applications in embryology follows, to form a solid foundation for group discussion on how to optimise support for the embryo during incubation.

Practical assignments in Pas Reform's laboratory then broaden participants' understanding, to be translated into practical guidelines for the various procedures needed throughout incubation, from arrival, quality control and storage of hatching eggs to the despatch and placement of day-old-chicks.

Participants perform a break-out analysis of clear and unhatched eggs, as well as judging the quality of hatched chicks, to collect valuable data on which to base continuing improvements.

Finally, troubleshooting and fine tuning in each aspect of hatchery management, including hatchery hygiene, plays a major role in this program. Throughout the week, full attention is given to the specific situation and requirements of each participant.

Training Groups

Hatchery Management Training is conducted for small groups speaking the same language. Native interpreters – usually a hatchery professional from Pas Reform's own International network – ensure accurate translation from English to the participants' own language.

Group size is limited so that sufficient attention may be given to the specific needs of each participant.

The Hatchery Management Training program is held at Pas Reform's headquarters in Zeddam, The Netherlands – allowing participants to take full advantage of Pas Reform's state-of-the-art Academy facilities.

For more information, please email info@pasreform.com or call +31 314 659 111





Acknowledgement

Pas Reform Academy combines in-house project engineering, hatchery management, training and a dedicated embryology centre. It drives Pas Reform's acclaimed product development track-record - and is the foundation of lasting, mutually rewarding relationships with our customers around the world.

Each of the Academy's specialists is a highly respected technician, engineer, hatchery specialist, embryologist or integration expert – and it is with thanks that we acknowledge the following for their contribution to the articles published here:

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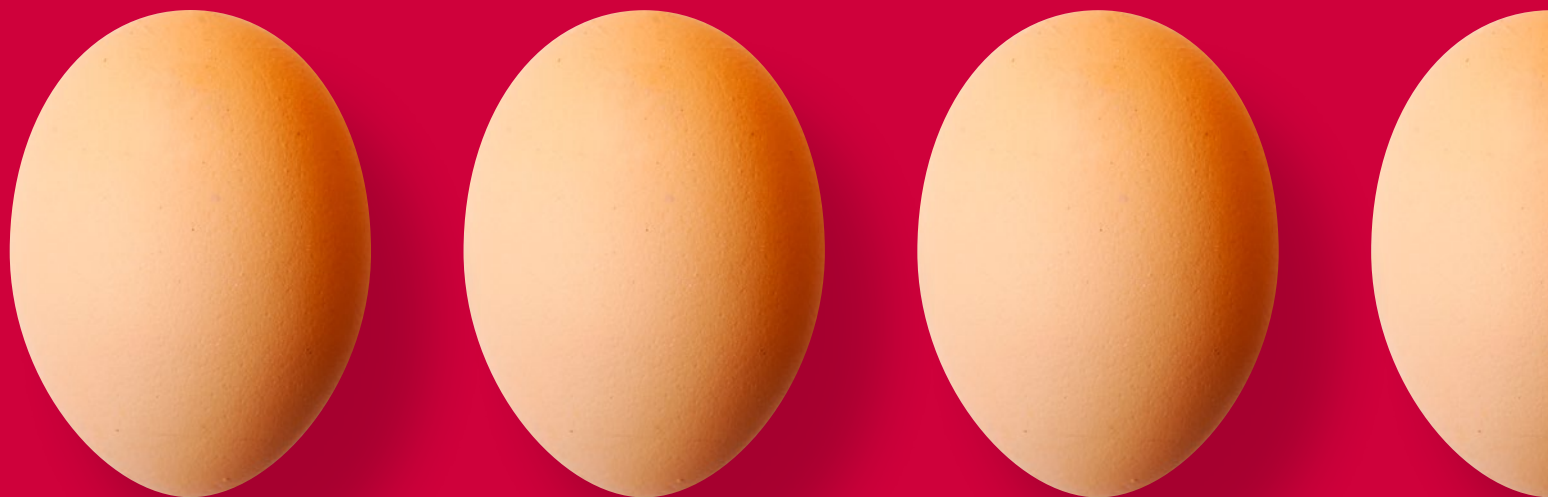
Derk Pijnenburg, Head of Engineering



Pas Reform Hatchery Technologies

Pas Reform is an international company, which has specialised in the development of innovative hatchery technologies for the poultry sector since 1919.

The company has earned its position as one of the world's leading hatchery equipment manufacturers, through decades of research into the biological and physiological aspects of embryo development, combined with a thorough understanding of all aspects of the poultry production chain – and a dedicated focus on the future.



Pas Reform Hatchery Technologies

Pas Reform
P.O. Box 2
7038 ZG Zeddam
The Netherlands

Phone +31 314 659 111
Fax +31 314 652 575
E-mail info@pasreform.com
Internet www.pasreform.com