Grading eggs for improved uniformity

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by Gerd de Lange, Senior Poultry Specialist, Pas Reform Academy

The modern poultry industry requires uniformity, which dictates that broiler farms deliver batches of broilers for processing with the smallest possible variation around target weight. Research has shown that one gram of difference in the weight of the day-old-chick eventually leads to between 2-13g difference in broiler weight at 6-8 weeks of age (Wilson, 1991). It is therefore fully understandable that broiler farmers look for batches of uniform day-old-chicks from the hatchery.

The major factor determining chick weight is the weight of the hatching egg. Under optimal egg storage and incubation conditions, chick weight is 67-69% of egg weight at setting. It is therefore safe to assume that 'the more uniform the egg weight, the more uniform the chick weight'. Breeder uniformity determines uniformity in the hatching eggs produced; the more uniform the breeder flock, the more uniform the egg weights.

However it is not uncommon to see substantial egg weight variation in batches of eggs originating from the same breeder flock – and grading eggs into two or three different weight categories seems a logical solution. There are however various aspects to consider:

- An egg in a certain weight category from a younger flock is not the same as an egg with a similar weight from an older flock (see Table 1). For example, eggs of 54 and 58g of different flock ages are in the same weight category, but differ significantly in yolk percentage. The same applies to eggs of 73 and 69g. Yolk percentage depends more on flock age and less on the weight category of the eggs.
- Collecting eggs of similar weight categories from different breeder flocks to supply a specific broiler house may result in more uniform body weights in a batch of day-old-chicks, but less uniformity in maternal aspects, for example immunity, nutrition and stress factors. Also in this scenario, tracing first week mortality problems in the broiler farm back to a specific breeder flock is impossible.
- Depending on flock size, grading eggs into different weight categories within one specific breeder flock means that eggs need to be collected over a longer period of time and therefore need to be stored for longer, to have sufficient eggs per weight category to produce a batch of day-old-chicks for one specific broiler house. Storage beyond 5-7 days reduces hatchability, chick quality and post hatch performance, while setting eggs of short and long storage periods together widens the hatch window, which negatively affects uniformity in the resulting batch of day old chicks. Grading eggs and incubating these separately while mixing the chicks again during placement does not make much sense.
- Grading eggs could also aim to simply reject eggs that are out of the hatchery-specific acceptable range.
- Individual weighing of eggs, needed for accurate grading, delivers detailed information about weight uniformity and is a useful evaluation tool for breeder farm management.

Advice

- Make egg weight uniformity a major focus of breeder farm management.
- Decide if grading eggs prior to setting delivers the necessary benefits by considering all the above mentioned points.
- Aim to place day-old chicks from one breeder flock only per broiler house. If this really is not possible, minimise breeder flock age difference to less than 10 weeks.
- Avoid collecting eggs from a breeder flock for one specific setting over periods any longer than 5-7 days.

Table 1. Egg weight variation. Means followed by the same letter within a column are not different according to Tukey's test (Vieira et al, 2005).

Breeder age (weeks)	Egg weight (g)	Yolk (%)	Albumen (%)	Shell (%)
27	54^{d}	26.9^{b}	61.3^{a}	11.8^{ab}
40 light eggs	58^{c}	31.4^{ab}	56.7^{c}	11.9^{a}
40 heavy eggs	73^{a}	29.7^{ab}	58.8^{b}	11.5^{b}
59	69^{b}	34.1^{a}	54.5^{c}	11.4^{c}

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Reducing hatchery energy costs for effective management

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by Sander Koster, Project Engineer, Pas Reform Hatchery Technologies

In multi stage incubation, heat is transferred from old eggs to the younger eggs, which demands less additional heating and cooling capacity by the incubator. This may seem like a good way to save energy, but in fact, the incubator is having to run full fan speeds 24/7 365 days a year, to deliver a constant airflow even when machines are not fully loaded.

Conversely, when employing single stage incubation, savings are realised by exchanging energy at hatchery level instead of inside the incubator. After a few days' incubation, the embryos collectively produce increasing levels of metabolic heat and require cooling to maintain optimal embryonic temperature.

A chiller for cooling water produces heat, which is dissipated by fans and lost to the outside environment. Using a heat pump instead of a chiller enables the heat produced to be recycled for pre-heating incoming air, or heating water in a buffer tank for washing and cleaning. As 1m³ of water contains 3,500 times more energy than 1m³ of air per degree Kelvin, it is more efficient to regain energy from water – and therefore less cost-effective to invest in a cross-flow heat exchanger that takes heat out of used air from the setters.

With single stage incubation, incubator motors only run when the machine is loaded. While maximum airflow is required to transfer heat to and away from the eggs at the beginning and end of the incubation cycle, energy can be saved by installing frequency drivers on the motors, because fan speed can safely be reduced during the days in between.

The single stage incubator uses pre-conditioned air for ventilation, which can require considerable energy depending on external climate conditions.

With an automatically controlled air valve or damper based on CO_2 and RH levels inside the incubator, the amount of fresh air intake required is optimised to provide only what is needed.

Using pressure controllers for the various rooms in the hatchery also minimises the amount of air needed, providing the doors to adjacent rooms are always closed – or ideally, automatic doors are installed (see box below).

Further energy savings can be achieved by using multiple set points in the Air Handling Units rather than fixed set points year round. For example, instead of maintaining a constant 24°C in the setter room throughout the year, allowing temperature variance between 23°C in the morning up to 27°C at the peak of the day during the summer, and maintaining temperatures at the lower end of specifications during the winter, will have beneficial effects.

Geographical location combined with climate conditions will have a major influence on the building and the amount of energy needed. With the wrong construction materials and/or insulation, it can be expensive to maintain the correct conditions inside the hatchery.

Ultimately, energy saving begins with a greater awareness of the energy we are using. With care and innovation in the process solutions we choose, we can deliver substantial energy savings – and greatly reduced energy bills!

Advice

In the Incubator:

- Install frequency controllers on the fan motors to reduce fan speed when possible.
- Install CO_2/humidity controlled valve regulation to limit ventilation to what is needed.

In the hatchery:

- Use pressure sensors for room ventilation.
- Keep doors closed to minimise loss of 'expensive' air.
- Calculate whether investing in a heat pump is more cost-effective than using a chiller.
- Use multiple temperature set points within specification during the year.
- Check the efficiency of hatchery insulation.

Heating 20,000m³/h from -24°C up to 24°C costs 378kW.

Heating 17,500m³/h from -24°C up to 19°C costs 296kW.

Result: 22% saving on heating power.

Pre-storage incubation and SPIDES: New procedures

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by Marleen Boerjan, director R&D, Pas Reform Hatchery Technologies

It is common practice for hatching eggs to be stored for several days before starting incubation. If temperature (18-20°C; 64.5-70°F) and humidity (75%) in storage rooms are controlled properly, eggs can be stored for one week without significantly reducing hatchability or chick quality.

Longer periods of storage however do affect the vitality of the embryo, causing increased early and late embryonic mortality, a delay in hatch and reduced chick quality (Fasenko, 2007; Dymond, 2013).

To overcome this, new approaches to egg storage management are being trialled among hatchery managers.

In the 1950s and -60s, Kosin (1956) and Coleman and Siegel (1966) showed that hatchabilities increased when eggs were incubated for short periods before being stored.

At the turn of the century, Fasenko (Fasenko et al., 2001; Fasenko et al. 2007) showed that after six hours of pre-storage incubation, chicken embryos reach the more storage resistant hypoblast stage of embryonic development.

The subsequent introduction of 3-6 hours' pre-storage incubation in layer hen hatcheries has shown that eggs stored for more than 11 days produce 3-7% more females (Lohmann Tierzucht, Hatchery Management Guide).

In the broiler industry, embryonic temperature stimulation during pre-storage incubation has been adapted still further to deliver multiple periods of stimulation.

Dymond and colleagues (2013) have shown that three-to-four 'Short Periods of Incubation During Egg Storage' – or 'SPIDES' – of 21 days increased hatchabilities and reduced hatching time when compared to the hatchabilities and hatching times of eggs stored for similar periods of 21 days (controls).

SPIDES has been introduced by Aviagen and is advised in the breeding company's 'HOW TO no. 9: "Improve hatchability by using Short Periods of Incubation During Egg Storage (SPIDES)'.

When practicing SPIDES, eggs are transferred from the storage room to a pre-warmed or running incubator and cooled again to storage temperature as soon as eggshell temperature reaches a maximum of 32°C (90°F). The time needed to reach 32°C (90°F) varies with incubator type, but is typically after 3-6 hours incubation at 37.8-38°C (100.0-100.4°F).

To prevent embryos from developing beyond the storage resistant stage, care must be taken that, during the complete or multiple SPIDES treatments, the cumulative time that eggshell temperature rises above 32°C (90°F) does not exceed 12 hours. (See HOW TO no. 9 for more details)

Conclusions

One treatment of pre-storage incubation or multiple treatments/ SPIDES (Short Periods of Incubation During Egg Storage) has been shown to improve hatchability and chick quality if eggs are stored for seven days or more. The interval between incubation treatments is typically 5-6 days.

Prestorage incubation and SPIDES change storage management at the hatchery significantly but this may be compensated for economically by restored hatchabilities.

SPIDES management protocols need to be designed specifically for the management practices and equipment of individual hatcheries.

Guidelines for designing a hatchery specific SPIDES protocol

- Calculate a cost benefit analysis to establish whether SPIDES management is profitable.
- Prevent an increase in hatch windows by pre-warming and cooling eggs uniformly in the incubator.
- Carry out small-scale trials to establish optimum timing and length of incubation treatments during storage for your specific hatchery and egg types.
- Start SPIDES only when all eggs are pre-warmed to 25°C.
- Perform SPIDES treatment only when eggs are placed on setter trays to assure uniform egg temperature during incubation. SPIDES on paper trays is impossible.
- Cool eggs in the incubator as soon as eggshell temperature reaches 32°C (90°F) and before putting the eggs back into the storage room. ■

Waste or by-product? Effective hatchery waste management

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by Sander Koster, Project Engineer, Pas Reform Hatchery Technologies

The hatchery's main goal is to produce the maximum percentage of good quality day-old-chicks from all the hatching eggs received.

Inevitably this process generates a secondary stream of material that as 'hatchery waste' is inherently worthless and perhaps even a generator of cost for its disposal, but with the potential to become a by-product can deliver value and a source of additional revenue for the hatchery.
In either case, both the terms 'waste' and 'by-product' indicate a material of secondary importance and, as with every production process, we can apply the 'Pyramid of Waste' principles in the hatchery.

At the top of the pyramid, our first aim is to prevent waste. Second, if waste is generated, we try to turn it into a (by-)product with a value. Finally, without a value option, we must discharge waste against costs or in the worst case, in an unsustainable manner, for example to land-fill. This is usually the last option.

Dealing solely with egg-related waste for the purposes of this article, we can apply the pyramid to the modern hatchery in the following ways:

● **Waste prevention.**
Since the amount of (solid) waste generated in the hatchery depends on hatchability, this is the key focus for waste reduction. Optimising breeder farm and hatchery management practices, including the creation of ideal incubation conditions, will substantially increase hatchability and therefore reduce waste.
While higher hatchability does produce more empty egg shells, these are usually easier to dispose of than (full) unhatched eggs, which naturally comprise a much higher volume or weight.

● **Identify valuable by-products.**
So called 'clears', consisting of infertile eggs and eggs containing early-dead embryos and removed during candling, may represent a by-product with value. Depending on local regulations, 'clears' can be sold as a by-product, either for human consumption (for example to bakeries) or for animal feed.. When clears are not removed prior to hatching (i.e. during transfer), they migrate from one waste category to another, to become 'unhatched' rather than clears.

Unhatched eggs can still have a value, for example in the production of biogas or composting in combination with the floor litter from chicken houses, or even as animal feed after passing through a rendering plant. Separated eggshells, depending on local regulations, may be used as fertiliser for calcium-supplementation.

● **Discharging against costs.**
As one of the least sustainable solutions for dealing with hatchery waste, the discharge of (organic) waste to landfill is becoming increasingly difficult in many countries and is usually a last option. While the focus when forced to discharge waste is largely on reducing costs and therefore finding the cheapest solution, the impact of waste on the environment cannot be ignored.

Process knowledge is crucial to optimisation – and performing a hatchery-specific waste analysis is a valuable tool not only for identifying more cost-effective and sustainable hatchery waste management processes – but potentially for revealing new revenue streams for the hatchery.

Advice

● Create awareness of the potential to extract value from waste among hatchery personnel.
● Optimise the incubation process for increased hatchability.
● Identify and separate hatchery waste into saleable by-products, waste that can be discharged sustainably at zero or minimal cost, and true hatchery waste.
● Look for sustainable ways to discharge true hatchery waste. While there will be a cost attached – your hatchery will be minimising its cost to the environment.
● Investigate ways in which specific waste streams may be combined with other sources of waste in the integration (farm, slaughterhouse, etc) or other existing solutions (for example a local bio-digester). ■

A specific approach to incubating big eggs pays off

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by Gerd de Lange, Senior Poultry Specialist, Pas Reform Academy

At the onset of egg production, breeder farm managers aim for a rapid increase in egg weight to achieve the commonly accepted minimum of 50-52g as soon as possible.

Subsequently, with proper breeder farm management, there should be a continuous and much slower increase in egg weight.

Maximum acceptable weight is usually based on whether eggs still fit on the setter trays, which in practice means an egg weight of 70-75g.

As a general rule, the older the flock, the bigger (= heavier) the egg. However in the hatchery, large eggs (›70g) from breeder flocks of 50 weeks and above pose an incubation challenge.

Hatch results, both in terms of hatchability and chick quality, are often not as good as those achieved with smaller eggs. The question is what can be done to maximise their results.

After peak production, while egg size continues to increase, we also see reduced shell quality (higher risk of hairline cracks), lower hygiene scores, thinner albumen, weaker germ and often also lower fertility. These factors, which will undermine hatch results, can only be prevented by good breeder farm management.

In addition, larger eggs require a specific approach during incubation. It takes longer to reach set point when a setter is loaded with big rather than small eggs, which increases total incubation time.

To overcome this, big eggs from older flocks should be set earlier or, when loaded together with small eggs in the same setter, pulled last. Proper preheating inside a running setter for 5-7 hours at 77°F can partially compensate for this difference in incubation time.

Fertility is also an important point to consider. If fertility in the larger eggs from older flocks is still high, for example due to artificial insemination or excellent management on the breeder farm, we can expect total metabolic heat production to be higher during the second half of incubation than in batches of lower fertility.

In single-stage incubation systems, this can be compensated for by incubating batches of fertile large eggs at a lower temperature profile, which is best achieved by setting them in a separate setter. Based on eggshell temperature, the temperature set points of the incubation program can be fine-tuned to avoid overheating the embryos.

When set together with smaller eggs, load the setter in balance, with big, highly fertile eggs positioned closest to the fan where air speed over the eggs is higher.

Large eggs create a greater resistance for optimal airflow over the eggs and positioning them in this way allows the effective removal of metabolic heat.

Finally, to optimise results with larger eggs, consider egg weight loss during incubation. Poor shell quality means higher porosity and large eggs require higher relative humidity to avoid excessive weight loss and the dehydration of embryos.

Conversely, reduced fertility produces less metabolic heat which requires a reduced relative humidity set point to avoid insufficient weight loss. Determining egg weight loss during incubation will help to find the right humidity set points.

Advice

- Set big eggs (old flocks) and smaller eggs (younger flocks) in separate setters.
- Consider the fertility of batches of big eggs when optimising incubation parameters; big eggs with high fertility require a different approach to big eggs with low fertility.
- Determine eggshell temperature to avoid overheated embryos when fine-tuning the incubation temperature profile.
- Determine egg weight loss and aim for 12-13% weight loss when fine-tuning relative humidity profile of incubation program.
- Place big eggs with high fertility closest to the fan and pull these chicks last when set in the same setter as small eggs. ■

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Measurement versus observation

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Measuring body temperature (BT) is a standard method of checking the health status of animals. Each species has its specific standard, or 'normal body temperature'. Increased temperature indicates fever, while deviation below normal signifies less than optimal condition. Like all birds, normal BT in domestic fowl is 40.5°C.

BT measurement in day-old chicks has become fashionable, possibly because many new hatchery managers are more familiar with this technique than looking at behaviour.

When checking BT, the hatchery manager must decide:

- What is the most reliable method of measurement?
- What is practical for application in field conditions?
- How will the resulting records be useful to the hatchery?

The physiological mechanism for maintaining BT develops late in the chicken, at around day three of life. Until then, the chick's physiology is largely dependent on its environment, much like that of a cold-blooded animal, for example a reptile. Measuring BT in the day-old chick is therefore more a reflection of climate conditions: temperature, humidity and the wind speed of an environment.

Deviation from the standard means either that the chicks were exposed for long enough to a chilling effect or that they got overheated. Both situations can also be observed in the chicks' behaviour. Huddling, gathering close to each other and peeping loudly indicate cold distress, while open wings and beaks and panting are typical symptoms of overheating. When chilled, the feet get cold first, which can be 'tested' by touching 'chick to cheek'.

Fluctuation of BT can still be seen when the chicks remain quite comfortable: just 30 minutes from take-off in the warm chick handling room is enough to reduce BT by 0.5°C, which causes no signs of discomfort in the birds. This instability has prompted the use of a conventional veterinary thermometer to measure BT internally (per rectum), with the logic being that more stable results can be expected from an internal measurement than on the surface of the chick's body.

To verify this thesis, two methods have been compared in a field trial: measuring BT on vent by an IR-ear thermometer (for example Braun ThermoScan) and by a conventional thermometer inside the rectum.

The trial showed that:

- Measurements taken by both methods depend heavily on environmental conditions.
- Results in both methods show variation, for example due to the presence or lack of fluff coverage on the vent area when measuring with an ear thermometer, or the depth of insertion if using a conventional rectal thermometer.
- Accuracy expressed by a spread of results is similar for both methods of measuring BT. Taking three correct measurements on the same chick the same spread of about 0.2°C was seen.
- Measurement taken by an ear thermometer is on average approximately 0.5°C lower than when measured on the same chick by rectal thermometer for deep body temperature.
- Measuring by an ear thermometer is more practical. Taking one measurement requires five seconds while taking a single rectal measurement takes 25-30 seconds and is very stressful for the chick.

Advice

- Observing the birds' behaviour gives accurate and direct information about the current comfort status of chicks
- Measuring BT of day-old chicks is best viewed as just a supplementary way of describing their status. As the result can be expressed numerically, it can serve to document extreme situations, for example in relation to claims.
- Use an IR-ear thermometer if measurement is required. It is easier, faster and less distressing for the chick. More measurements can be taken without compromising accuracy.
- Measuring chick BT as a standard procedure in evaluating chicken quality is unnecessary.

Maintaining correct air pressures in the hatchery

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In principle, setters and hatchers can function well in a hatchery with open construction, when air pressure in all the rooms is equal to the air pressure outside. In practice, however, the majority of modern hatcheries are 'closed' and equipped with air handling systems to control temperature and relative humidity within optimal ranges, as recommended by the incubator manufacturer. The aim, of course, is to create uniform incubation conditions with minimal energy costs.

There is the risk in a closed hatchery, that not enough oxygen-rich air is brought to the incubators and that 'used' air, with high carbon dioxide content, is insufficiently exhausted from the facility. However any potential for mixing fresh and used air is avoided when the hatchery's inlet and outlet plenums, for both setter and hatchers, are separated.

By maintaining positive air pressure in the inlet plenum, sufficient fresh air for the setters and hatchers is guaranteed, providing the machines are designed to actively draw in the fresh air and do not depend on high air pressure to push the air inside.

Positive pressure in the outlet plenums should be avoided, to allow setters and hatchers to exhale freely. Neutral pressure will suffice, although a light under-pressure is usually preferred. Excessive under-pressure should be avoided, to prevent the risk of overruling the incubator's own ventilation principle.

Hatchery hygiene is another, equally important reason for maintaining different pressures in different rooms. The clean air plenum for the setters, whether the setter room itself or a separate air plenum above the setter room, should be preserved as the cleanest room in the hatchery, by maintaining overpressure in relation to 'dirtier' rooms, such as the transfer room (bangers) or hatcher rooms (fluff). This ensures that air flows from clean to dirtier rooms and not in the opposite direction.

Likewise, the outlet plenum of the hatchers, often referred to as the 'fluff tunnel', should be kept at slightly negative pressure, to avoid cross-contaminating other rooms in the hatchery with small amounts of airborne fluff from the hatchers.

Slight under-pressure allows the fluff to settle on the floor of the plenum, where it can easily be washed into the drain. Too much under-pressure risks sucking the fluff onto the roof, which may then re-enter the hatchery through the air handling unit, with the potential to block filters and contaminate clean air.

Notably, air pressure measurements within the hatchery are +/- from 'zero', where zero is the outside pressure. It is therefore important that the probe for reference pressure is located where it will not be affected by wind. Changing wind speeds will have a different effect depending on whether they are measured on the windward or leeward side of the hatchery and fluctuation in external reference pressure will disturb pressure control inside the hatchery. An air filter on the end of the external probe is also recommended, to prevent the probe from becoming blocked by dirt or even insects.

Advice

- Maintain air pressures in the inlet and outlet plenums of setters and hatchers in a 'closed' hatchery environment, in accordance with the incubator manufacturer's recommendations.

- Keep doors closed: this is the only way to maintain the required pressures inside the hatchery. Consider installing automatic sliding doors.

- Ensure that air flows at all times from clean (setter room) to dirtier areas.

- Ensure that external reference air pressure is taken correctly and consistently from a 'zero' location with minimal fluctuation.

- Maintain Air Handling Units (air filters!) regularly to guarantee that sufficient fresh air is supplied to all relevant rooms in the hatchery.

Let your setters sleep... 64

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by Maciej Kolanczyk, Senior Poultry Specialist, Pas Reform Academy

The ideal status of a working setter is just 'sleeping'. Parameters are being maintained in all sections, but no climate device is really active. Internal climate is balanced simply by using the heat and humidity produced by the eggs with precise ventilation control.

This is the ideal scenario in terms of equipment and energy efficiency, to create an optimised environment for incubation. But in practice, this is not so easy. The larger the setter, the more difficult it becomes to achieve this balance, due to some basic and unavoidable physical principles, including:

- Cold air is heavier than warm air.

- Air in flow has a chilling effect which becomes more pronounced as air speed increases.

- Obstacles reduce air flow.

- Evaporating water takes heat from the air and creates a cold spot.

- Heating increases air temperature by convection and by radiation.

To deliver an accurate incubation program, the setter is equipped with technical devices, such as heaters, coolers and humidifiers. These respond to current program requirements and work fairly intensively.

In a single stage setter, the need for fresh air varies, increasing quickly after 10 days of incubation. At that point, the embryos start to produce more metabolic heat, which has to be absorbed by the cooling system or removed with used air.

If air exchange is overly intensive during early incubation, the setter will respond with increased heater activity. Although set points are maintained, eggs placed next to heaters that are working continually are exposed to higher than optimum temperature due to local heat radiation.

Over-ventilation during the last ten days of incubation activates the humidifiers and permanent, localised evaporation creates a cold area. This temperature variation accelerates or decelerates the development of the embryos, finally contributing to a broadened hatch window that will compromise chicken quality.

Growing embryos require an increasing supply of fresh air, which while necessary for life, is also the main destabilising factor for the environment inside the cabinet.

With insufficient ventilation, embryos will suffer or even die. If ventilation is too intensive, too much fresh air enters the cabinet. This then forces the controllers to adapt to programme parameters by increasing the activity of heaters and humidifiers. The temperature of the fresh air taken by the machine is usually in a range of 21-27°C, with humidity at 45-60%. Inside the setter, we are aiming for a temperature of around 37.8 °C with 45-60% humidity.

Heater, cooler and humidifier can be compared to our neighbours: we need and like them if they are quiet and gentle. But a neighbour who keeps us awake with constant parties and loud music is not a good one!

Advice

- Pay attention to what the machine is doing. Parameters should be maintained with minimal effort.

- Control ventilation and measure air freshness using the CO_2 sensor: 0.4% is a very safe level. An ideal solution is to control the ventilation level automatically, based on measured RH and CO_2 according to actual embryo requirements.

- Make it easy for the machine: do not ask too much! If humidifiers tend to work hard in the final phase of incubation, optimise the climate conditions of inlet air.

- Apply an incubation program with a lower RH set point in the last days of incubation if optimising inlet air is not enough, balanced by a higher RH at the beginning. Reaching 45% RH is easier than reaching 53%.

- Adjust ventilation set point if the setter is not fully loaded.

- Let the setter 'sleep' for optimum performance.

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