

The art and science of single stage incubation

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In hatcheries around the world, many have converted to using single stage incubation after many years experience with multi stage incubators.

Single stage incubation has proven to have a positive impact on hatchability, chick quality, and field performance. Single stage addresses the needs of the embryo better than multi stage because developing embryos require changes in the incubation process as development progresses.

The principal shortcoming of multi stage incubation is that the hatchery manager is not able to adjust the environment, since both the day one embryo and the 18 day embryo must exist in the same environment.

There also have been considerable changes made to the breed lines used throughout the industry.

Genetic improvements

Genetic improvements in meat yields, egg production, leg health, and numerous other factors have led to embryos requiring different incubation requirements even in the same breed lines.

Current studies suggest that high yielding strains have a higher metabolic rate and, consequently may need to be managed differently to effectively dissipate excess heat and carbon dioxide.

Every hatchery regardless of the type of incubation equipment has same basic goals; produce as many high quality chicks as possible.

The multistage hatchery is limited in how they can change the operational parameters of the incubator that fully meet the needs of all embryos due to the limitations of the multistage process.

Single stage incubation on the other hand, gives the hatchery manager the ability to alter the incubation process.

Manipulation of temperature,



Chip Campbell, right, on a recent visit to Spring Chicken Hatchery in New Zealand.

humidity, carbon dioxide, and time allows the manager to adjust the conditions to meet the specific requirements of the embryo at any given time during the incubation process.

While the concept of single stage incubation may sound complicated, the process is quite simple. Single stage incubation is characterised as a more natural style of incubation since we can provide the embryo with the proper conditions at all times, much like the brooding hen.

A basic knowledge of embryo development is needed, more importantly, a basic understanding of the three phases of development, and the requirements of each of these phases.

Embryo development can be divided into three phases – cell differentiation, growth, and maturation/hatching.

Cell differentiation

During this phase, we see the formation of the initial embryonic components, non-embryonic, extra embryonic and sub-embryonic fluid from a single mass of approximately 50,000 cells.

From these components, the different organs and structures of the chick will develop as well as the sup-

porting structures of the allantois, amnion, chorion, chorio-allantoic membrane, and sub-embryonic fluid.

This is a temperature dependant phase, meaning that the embryo requires heat for the proper timing and formation of the different components of the embryo. The embryo is temperature sensitive at this stage.

Excessive temperature, temperatures 38.0°C and above, will result in the speeding up of the incubation timing, abnormal development in one or more organ or structural system, and early embryonic death.

The same is true with incubation temperatures below 36.0°C, there will be an abnormal development of the organ and structural systems of the embryo.

The cell differentiation stage ends by day seven of incubation. At this

Chick Master's Genesis IV setter control touch screen.



point, all of the primary components and body systems are in place.

Growth

The growth phase is marked by an increase in the mass of the embryo while organ systems continue to develop. During this phase in development, the embryo transitions from an endothermic state, to being exothermic. This transition to an exothermic state begins around day 12.

Also during the growth phase, the partial pressure of oxygen in the air cell begins to decrease and the partial pressure of carbon dioxide increases because of embryonic metabolism. It is necessary to begin to increase oxygen and decrease the carbon dioxide inside the setter by opening the dampers. This allows for the passive diffusion of gases and water vapour between the inside and the outside of the egg. The end of the growth phase occurs by day 17 of incubation.

Maturation/hatching

During this phase, the growth rate of the embryo begins to decrease. The embryo begins positioning itself for hatching. The residual yolk begins to be absorbed into the body cavity. Between days 18 and 19, the embryo is near its peak embryonic heat production that will be experienced by the incubator. This stage will require considerable air exchange within the setter environment in order to remove the excess heat and carbon dioxide.

A basic understanding of the events that take place during the various stages of incubation will allow us to understand the principals of single stage incubation.

The first four stages of a typical broiler profile determine the set points and requirements needed by the embryo during the cell differentiation phase of incubation. Step 1 will take the stored eggs from the physiological zero point up to incubation temperature in a uniform manner.

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During this time, the dampers are closed, and there is no air exchanged in the incubator. As the temperature increases to the set point, the internal egg temperature is also rising in an equal and uniform manner throughout the egg mass in the setter.

This is the key to a narrow hatch window and uniform development of the embryo. Since the incubator is sealed, humidity and carbon dioxide levels will also begin to rise.

During step 1, we are warming the mass up to incubation temperature. We do not consider this time to be part of the overall incubation time.

Incubation begins once the setter has reached its temperature set point, in this case 38.0°C.

Once the incubator has reached this temperature, active heating of the incubator decreases, and we begin incubation. Steps 2-4 cover the first six days of the incubation cycle. We have a sealed environment, humidity will increase up to 85%, and carbon dioxide will steadily increase in some cases up to 1% depending on flock fertility and egg mass capacity.

It is critical to maintain an even and homogenous environment to ensure that embryonic development continues evenly and rapidly throughout the egg mass.

The ability to maintain temperature, humidity, and carbon dioxide are enhanced by our ability to control the fan speed and fan direction to ensure this uniform environment.

Elevated carbon dioxide

Elevated carbon dioxide levels during the first six days of the incubation cycle have shown to have a positive influence on embryonic survival especially in old eggs. This is due to several physiological reasons. As the egg age increases before being set, there is a thinning of the albumen that occurs naturally.

This thinning also causes an increase in the pH concentration between the yolk and the albumen. The natural thinning and increasing pH concentrations are the main causes for hatchability to decrease as the egg ages since these conditions create a negative environment for the survival of the developing embryo.

Increased carbon dioxide levels during the early stages of incubation have been shown to slow the deterioration of the albumen and help maintain a more favourable environment for the developing embryo.

This includes carbon dioxide injection during the first few days of incubation prior to the natural buildup of carbon dioxide from the embryo.

We have seen significant hatchability improvement when old breeder eggs and/or eggs with high egg age are incubated in the presence of ele-

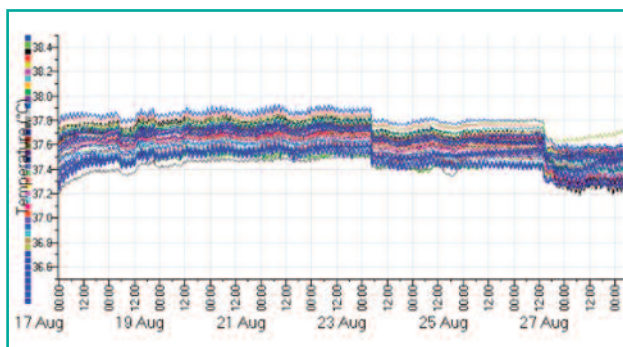


Fig. 1. Actual egg pack temperatures in the first 10 days of incubation recorded on a Chick Master temperature datalogger (shown right). The other two dataloggers record humidity and shock respectively.



vated carbon dioxide concentrations in the first week of incubation.

We also see that elevated carbon dioxide stimulates a faster and stronger development of the circulatory system, internal organs, extra embryonic membranes, and facilitates better mineral deposition in the embryos skeleton.

Another factor that aids in the overall survival of embryos is the high humidity levels that occur in the closed damper stages of a typical setter incubation profile. Early moisture loss is a contributing factor in embryonic death due to dehydration in the first four days.

This is even more of an issue with an old breeder flock (high shell conductance) and long stored eggs. Long stored eggs need a much lower storage temperature and higher humidity levels to avoid moisture loss. The initial humidity levels in a single stage profile will run between 85-90% RH.

This has two significant benefits. Firstly, as the humidity increases, it will slow the loss of additional moisture from the egg since the partial pressure will be greater outside versus inside of the egg.

Secondly, because we do not have the aid of embryonic heat from older eggs, such as in a multi stage incubator, the embryo is dependant on the setter's heating systems to supply the heat needed to progress in incubation.

Even distribution

Getting even air distribution is the key to uniformity of the hatch. The longer the air has to travel to get to the egg, the more difficult it is to maintain this uniformity. That is why a design with many trolleys on each side of the fan struggles to be uniform compared to one with a single trolley on each side of the fan.

By the end of day six, we move into the growth phase of embryonic development. We separate this phase with significant changes in the operation of the incubator. The growth phase can be divided into two separate parts. The first part is the endothermic stage when the embryo absorbs heat.

The second part is the exothermic

stage when the embryo produces heat typically between days 10-12.

During the endothermic period of the growth phase, we need to remove the high levels of humidity and carbon dioxide and increase the levels of oxygen without removing too much heat from the environment. We set the damper control to humidity control and begin to open the dampers and enable the embryo to start moisture loss.

We will begin with humidity set points approximately 20% less than the peak humidity level during the closed damper phase. This will remove the un-needed humidity and carbon dioxide; introduce fresh air without removing too much heat.

Nearing day 10, we will lower the humidity and temperature set point some more. We will also increase the minimum damper opening progressively during this growth phase.

This will further aid in achieving the required moisture loss, and it will start to remove the heat that is being generated by the embryo. As the growth phase progresses, heat and carbon dioxide production increases.

Fan speed variation

Another tool to improve this process is the ability to vary the fan speed and direction. The variable fan speed is controlled by the cooling and/or heating action of the incubator.

As the incubator calls for heat or cooling the fan speed will automatically increase from its set point in the profile to full speed.

During the growth phase, we increase the speed set point and continue on automatic control. As embryonic heat increases, the cooling activity of the setter increases.

As the incubator calls for cooling the fans will increase speed to increase the airflow over the eggs to facilitate removal of the excess heat.

As we near the end of the growth phase and start the maturation phase, embryonic heat production will reach its peak by day 18. The embryo is positioning itself for hatching and absorbing the residual yolk. At this point, the incubator is dealing with a heat load approxi-

mately 2.5 times that of a multistage incubator.

The embryo is susceptible to complications associated with extreme temperatures, so we will continue to increase the minimum damper openings, and decrease the temperature set points. We will increase the fan speed fan to its maximum.

Transfer times

Transfer times can vary between 18-19.5 days depending on numerous factors. By the time we reach day 18 or 19, we will begin to prepare the embryos for the hatching process. The last stage of the program will mimic the first stages of the hatcher profile. We continue to calculate heating degree hours. By day 19.5, we have achieved 17,527.2 heating degree hours. The average incubation temperature for this profile will be 37.5°C.

Single stage incubation is the simple application and manipulation of time, temperature, humidity, and carbon dioxide, to give the embryo what it requires, and remove what it does not need.

The understanding of heating degree hours, which is simply temperature multiplied by time, allows us to alter time and temperature set points as needed that will provide the best quality chicks.

The specific details of a single stage profile will vary based on breed types, age of flock, and length of egg storage.

Part science, part art

It is part science and part art, but step programming in single stage incubation is relatively simple. It is not the same process for all flocks and breeds so it cannot be effectively automated based on a few select eggs in the incubator.

By knowing your flock ages and breed types, the tools exist to get a high quality chick and hatch every single day.

When comparing different single stage incubators, make sure that the systems have the tools to achieve your objective of producing large amounts of quality birds. ■