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MULTIPLE STAGE / SINGLE STAGE SYSTEMS OF INCUBATION ~ ADVANTAGES AND DRAWBACKS ~

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INTRODUCTION

The poultry industry is always looking for ways to increase its productivity. Undoubtedly, the possibility of increasing the hatchability, and therefore the number of day-old chicks, and their quality by improving chick uniformity is very attractive.

In this way, companies are evaluating the possibilities of moving from the multiple-stage system towards the single stage system of incubation. Obviously, there are advantages and disadvantages in both systems and this article summarizes them.

MULTIPLE STAGE / SINGLE STAGE SYSTEMS

A large majority of hatchery operators use multiple-loading machines; therefore, most often, incubators are loaded by thirds every week (by setter tray or trolley), which makes it possible to have both eggs requiring heat and others releasing heat in the same environment.



Figure 1 : Example of single-stage setter (Chickmaster)



Figure 2 : Example of multi-stage setter (Petersime)

However, the great diversification of breeds and constant research to optimize their performance have led to define optimal incubation parameters for each type of breed according to the needs of embryos at each stage of embryonic development.

This research has resulted in the development of so-called single-stage incubators as they involve loading of eggs at the same development stage: temperature, humidity and ventilation instructions evolve according to embryonic development. Eggs are loaded at D0 and taken out at D18; the machine is then cleaned, disinfected, and a new cycle may start.

SETTING OF PARAMETERS

a) Temperature

For multiple stage incubators

There are thermal exchanges between exo- and endothermic eggs, which creates a “buffer” effect limiting temperature gaps.

- ☑ During the first phase of incubation, the standard reference temperature is approximately 100°F (37.77°C), with a few variations according to strains, age of breeders and egg storage time.
- ☑ During the second phase of incubation, it is most important to prevent egg temperature from rising above 101°F (38.33°C) in order to avoid late embryonic mortality. This not only depends on the machine's cooling system but also on the ventilation.

Once the temperature instructions are set, it is important to fill the machines properly in order to avoid insufficient temperature around eggs or excessive heat at the end of incubation.

For single stage incubators

In this system, there is only one incubation age, either heat-lacking or heat-producing. As a consequence, the incubation has to be carefully monitored: for example, the egg's temperature is constantly measured and no longer the temperature in the machine.

The temperature settings will be higher at the beginning of the incubation process and progressively declining from mid-incubation onward, with the objective of constantly maintaining egg shell temperature close to 37.8°C.



Figure 3 : Example of full-monitoring system (PAS REFORM)

Example of a program:

- D1-D2 → 37.7°C
- D3-D12 → 37.5°C
- D13-D21 → decrease by 0.1°C per day until hatching.

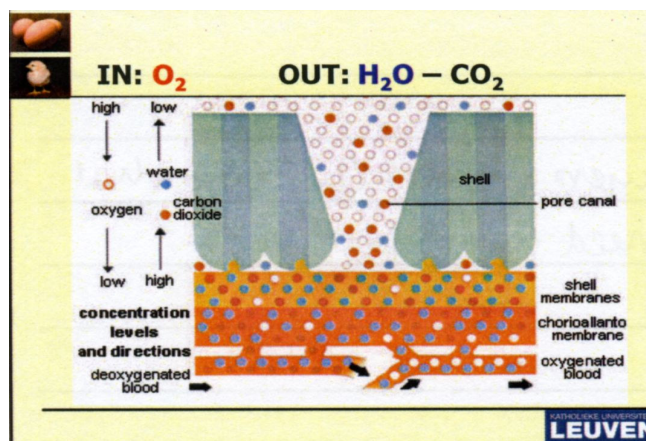
Note:

Celcius degrees (°C) are converted into Fahrenheit degrees (°F) with the formula:

$$F = 32 + (°C \times 9) / 5$$

b) Humidity

This is a crucial point to observe. Between 7000 and 17000 pores are involved in the gas exchange, and natural variation can be observed : young hens will give eggs with less pores than old ones for instance. The mechanism is showed in this slide.



For multiple stage incubators

The relative humidity in incubators is set between 58% and 60% depending on standards, but this is only an indicative range: the only parameters to be considered are embryo water loss and total hatchability.

For single stage incubators

Humidity management is different. Indeed, in the first 8 days of incubation, a high level of humidity allows greater osmosis between egg white and egg yolk, thereby enabling the embryo to feed, and consequently grow. Therefore, this high humidity should be promoted in order to accelerate the development of the future chick. Later, as soon as the heart is functional, blood circulation takes over and ambient humidity should be brought down to a level between 50% and 55% so as to achieve the standard loss at the end of the cycle.

c) Ventilation

For multiple stage incubators

Air provision in the incubator is constant and approximately 0.14 m³/minute/1000 eggs, adjusted so that the volume of carbon dioxide does not exceed 0.4%.

For single stage incubators

The incubator can be programmed according to the needs of future chicks in carbon dioxide and oxygen, depending on the age of breeders and storage time.

Importance of OXYGEN	Importance of CARBON DIOXIDE
<ul style="list-style-type: none"> Normal ambient O₂ concentrations are needed for normal embryonic development Hypoxia can occur with low porosity shells and can cause embryonic mortality Hypoxia slows growth rates Naturally occurring hypoxia at end of incubation (blood and cell air) 	<ul style="list-style-type: none"> Naturally occurring metabolic acidosis with embryonic development : blood pCO₂ compensated by increased HCO₃⁻ Before external pipping : CO₂ concentration can reach 8.5 % in air cell Increasing tolerance of embryo to high ambient CO₂ IMPLICATION in SINGLE stage : decreasing aeration causes increase in CO₂ during first half of incubation.

Figure 4 : Gasses during embryonic development (Pr DECUYPERE)

ADVANTAGES AND DRAWBACKS OF SINGLE-STAGE INCUBATION

Single-stage incubation is the most recent and sophisticated mode of incubation, and yet the least widespread to date. However, there are some clear advantages over the traditional multiple-stage machines.

Sanitary Advantage

With the “all in, all out” technique, single-stage incubation allows disinfection every 18 days (“all in/all out”), whereas multiple-loading incubators are rarely empty. Moreover, no opening of the incubator occurs until transfer.

Better Control of Incubation and Grouping of Hatches

Temperature, humidity and air composition are well controlled and adjusted to the needs at each embryonic development stage, which enables optimization of chick quality and hatchability rate. With multiple loading, this can be very hard to achieve with heavy broiler strains for example, as these may show an up-to-2°C difference in shell temperature between eggs of a same tray.

Better Chick Quality

The better availability of nutritive material helps accelerate embryonic development: with a same weight at hatching (same water loss), chicks hatching by this technique have a yolk sac of 1-3 g instead of 5-7 g usually, and their organs are more developed: longer bones, bigger heart (up to 15%) and gut (up to 5%). Mortality is also reduced in the first phase of incubation and around hatching, due to a narrowed spread of hatch.

Drawback: Costly Investment, Costly Energy Consumption

Single-stage incubation requires that the hatchery be equipped with several independent units in order to meet the needs of hatching eggs of different ages; hence an increased “cost per egg”. Although it is possible to reduce ventilation at the beginning of incubation, the total energy cost is higher as heating (during the endothermic phase) and cooling (during the exothermic phase) are performed by the machine only. In fact, this cost seems largely compensated by the sanitary advantages in hatchability rate and chick quality.

CONCLUSION



Without any doubt, single-stage system of incubation presents clear advantages over the more traditional multiple-stage system. However, as it happens with any innovation, companies have to evaluate the impact of its adoption on their final results.

The necessary investments and eventually the increase of the energy consumption have to be compared with the possible gains in production. By doing this calculation carefully, companies can find the best solutions for their needs.