Factors that Affect Hatchability

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Learning objectives for this module

- To understand differences between hatchability and hatch of fertile data
- Identify biological and management factors that modify hatchability
- Review incubation factors and troubleshooting
- Recognize how multiple factors can cause overheating and affect hatchability
- Appreciate the value of observation and data analysis

Hatchability can be affected by:

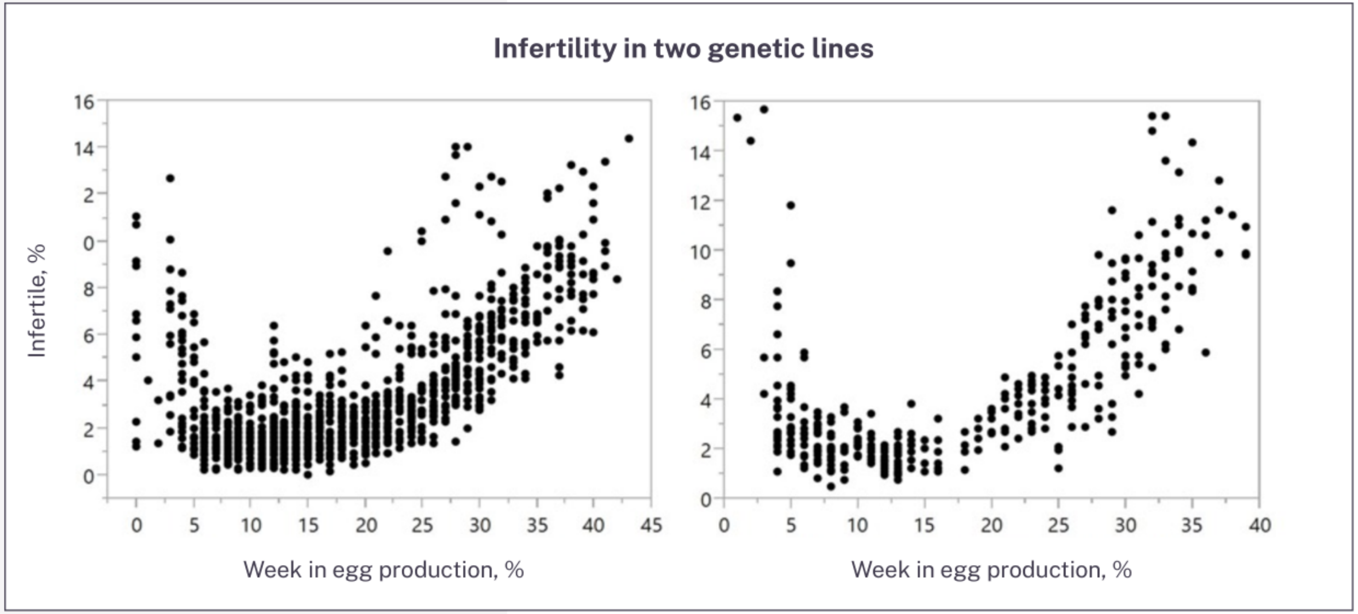
- Hen and rooster age
- Incubation conditions by breeder age
- Nutrition and management of hens and roosters
- Farm management and egg transportation
- Egg storage and management during storage
- Incubation factors
- Machine management and maintenance

Hatchability varies mainly by breeder flock age due to diverse causes related to egg traits.

However, **the main biological factor affecting hatchability is the lower flock fertility during the first five to ten weeks of egg production** and a typical reduction in fertility due to male and female aging after 50 weeks of age in broiler breeders, 55 weeks in laying flocks, or after 15 weeks of lay in turkeys.

Hatchability is determined as the proportion of total eggs set that hatch to the end of incubation, which is always more variable than the hatch of fertile. Then, **it is always essential to determine the average fertility by examining embryonated eggs after three days of incubation or by ovoscopy at either 11 or 12 days of incubation and calculate the hatch of fertile.**

It is important to differentiate fertile from unfertile eggs. It is also critical to track the evolution of infertility as the breeder flocks age. This information can be tied to flock health.



Opportune nutritional interventions may mitigate the reduction in fertility. In the same way, **it is crucial to differentiate between early mortality caused by egg management factors and infertility.**

The embryo development and survival of eggs due to contamination, water loss, and gas exchange depend mainly on eggshell characteristics.

Albumen properties like thickness and pH may also alter embryo and extraembryonic membranes. **The egg and eggshell factors that vary with breeder flock age and may affect embryo development are:**

- Egg weight
- Eggshell thickness, pores, and conductance
- Eggshell breakage and contamination
- Shape index (maximum breadth-to-length ratio)
- Albumen and yolk properties.

Eggshell conductance

Eggshell conductance is the ability of an eggshell to exchange gases, such as oxygen, carbon dioxide, and metabolic water, with the surrounding environment.

This exchange is essential for embryo development, as the embryo development rate is directly related to the amount of oxygen that enters the egg.

Eggshell conductance is related to the loss of metabolic water and gases inside the egg to the external environment.

As the breeder flock ages, eggshells are more susceptible to breakage and contamination. This susceptibility is caused by changes in the eggshell ultra or microscopic structure *(Figure 1)*.

An eggshell is formed by shell membranes, and the calcified regions consist of the mammillary, palisade, and vertical crystal layers. Overlaying the calcified region is the cuticle of the surface of the eggshell.

The thickness of the calcified region does not alter as the broiler hen ages.

However, **the percent contribution of each calcified layer significantly differed over the egg production period.**

- No significant correlation has been observed between egg viability and the relative thicknesses of the mamillary, palisade, or cuticle layers.
- In contrast, there is a **positive relationship between egg viability and the thickness of the vertical crystal layer.**

The cuticle is thinner before 30 and after 55 weeks of age. **The cuticle is a noncalcified layer that covers the eggshells** of most bird species.

However, **no significant correlation between cuticle thickness and embryo survival has been observed.** The properties of the cuticle and time to dry also vary with age and may affect water vapor conductance.

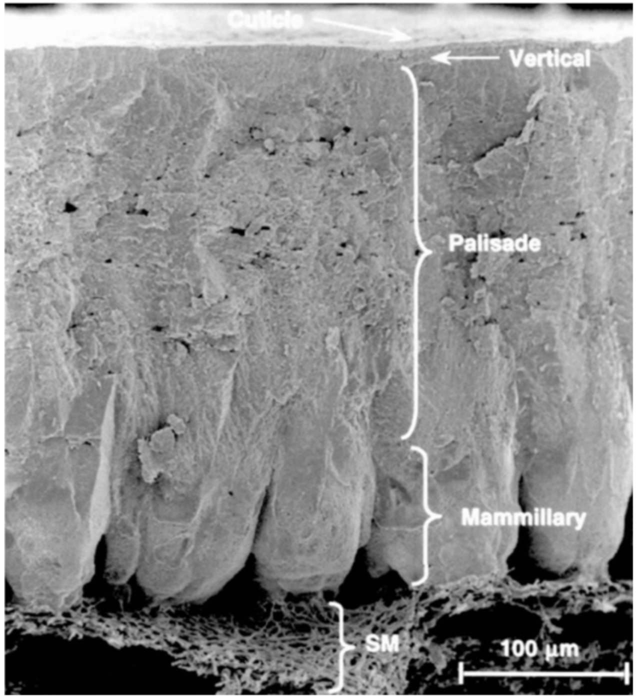


Figure 1. *Ultrastructure of the eggshell.*

Egg storage

Hatchability is reduced by egg storage.

Egg storage is necessary to obtain the number of eggs required under each market circumstance.

Egg storage time and the management practices conducted during this period cause the following changes in the egg physicochemical properties:

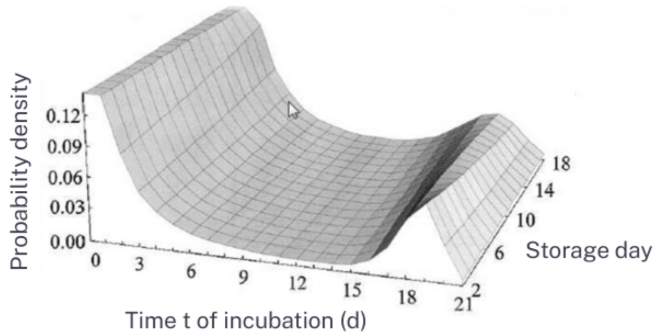
- pH: the egg looses CO_2 and becomes more basic.
- The albumen height and its viscosity are reduced
- The vitelline membranes become more propensity to rupture with storage
- There is more water movement from albumen to yolk, causing yolk mottling

These changes in albumen caused by egg storage reduce the development of blood vessels in the embryo at day three of incubation. It slows down the development of the chorioallantoic membrane, all extraembryonic membranes, and the embryo.

It increases embryo mortality during the first days and especially between 17 and 20 days of incubation. **The early embryo mortality of eggs stored for more than six days is always higher.**

It can be up to four times more in broiler eggs stored for more than 11 days, and the late embryo mortality can triple compared to eggs stored for less than seven days. **Generally, no significant changes in embryo mortality are observed with egg storage.**

Probability to increase embryo mortality during incubation according to egg storage



Kuurman et al., 2001.

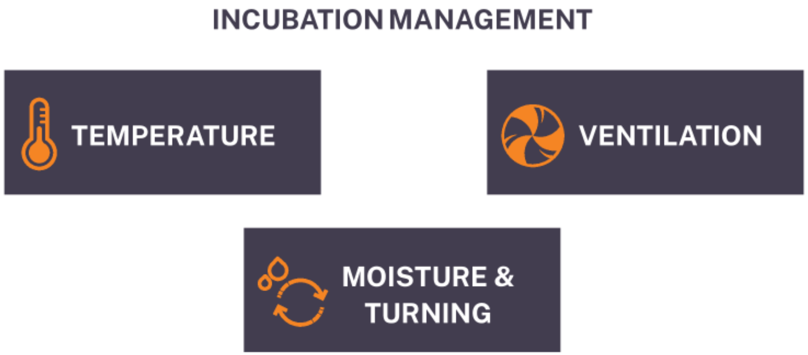
Parameters Affecting Embryo Development

Hatchability depends on proper embryo development, and incubation parameters directly impact embryo development.

The main incubation factors are:

- Temperature,
- Moisture,
- Turning
- Ventilation.

Parameters affecting embryo development



They are monitored and frequently discussed separately, but inside an incubator machine, they constantly interact.

The machine temperature should provide an adequate amount of heat to guarantee embryo development. It is well-accepted that an incubator machine should have eggshell temperatures reaching 37.8 °C (100.0 °F).

In ***single-stage incubators,*** all the eggs are set simultaneously, and it is possible to develop a program to provide temperatures that match egg temperatures and embryo heat production as they develop from endothermic to exothermic organisms. Then, the optimum eggshell temperature can be kept constant.

In ***multistage machines,*** eggs are set several times per week, and embryos of three and six different ages are maintained at the same machine temperature. Generally, heat is shared among those eggs, and adequate temperatures are usually observed.

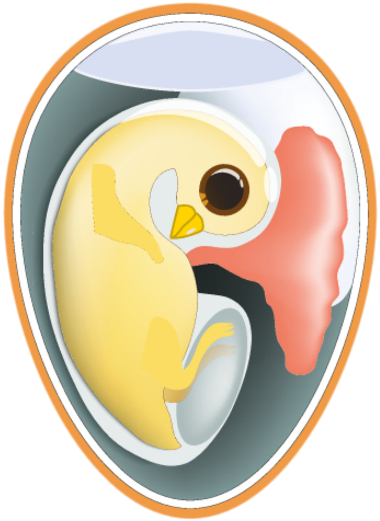
However, after 15 days of incubation, the embryo heat production rapidly increases, and the machine temperatures need to be reduced to maintain the eggshell temperature constant. This is impossible in a multistage machine where embryos endure overheated egg conditions (> 38.1 °C, 100.6 °F).

The temperature changes become critical between days 18 and 20 because there is an essential transition from chorioallantoic membrane to lung respiration.

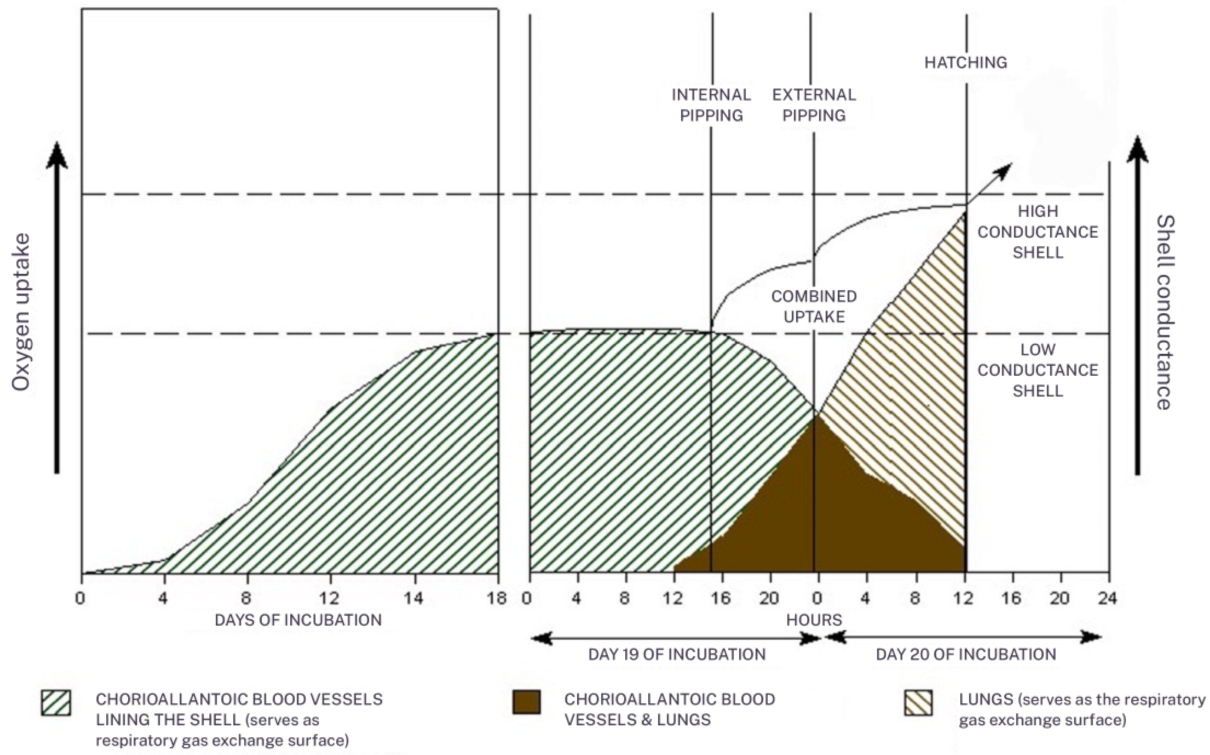
Machine temperatures above the optimum accelerate metabolism, and the demand for oxygen affects chickens' survival during this phase.

The ability to cope with this oxygen supply stress depends on the eggshell conductance.

Embryos in eggs with low eggshell conductance will have more hypoxia stress during this transition period, known as the plateau stage of oxygen uptake. This may affect their survival and future development.



Oxygen consumption by the embryo



Adapted from Rahn, Ar and Paganelli, Scientific American, vol. 240 (1979), pp. 46-55

Microenvironments within the incubator machines

Nevertheless, **the issue could be worse in machine sectors due to microenvironments created when turning and ventilation are inadequate.**

Cooling problems and ventilation in setters and hatchers are also issues. Maintenance of machines and incubator rooms can prevent all these failures and provide optimum conditions for all eggs in a machine.

Microenvironments are frequently related to issues with airflow through the trays. They can be related to a suboptimal turning angle that blocks the air. Spray nozzles with defects can also cause temperature variations, either by excessive cooling in one area or by leaving overheating in others. **Incomplete sets and empty spaces in the machine cause variations in airflow and overheating of some eggs.**

Open hatcheries without environmental control or hatchery rooms with failures in temperature control can cause machines to try to compensate for the hot or cold incoming air.

This may cause overheating or excessive use of the spraying system when the design of these machines has it. **Overheated microenvironments in the setters during early embryo development can be the main cause of malformations** like exposed brains, ectopic viscera, and beak abnormalities. **Overheated hatcher microenvironments can cause higher mortality during the internal and external pipping, and embryos show higher ureates at hatch.**

There are several methodologies for measuring eggshell and machine temperature. However, **once the microenvironments are detected, eliminating or minimizing their causes is the most relevant action.**

When working with old hatcher designs, it is essential to improve cooling capacity. Ensure that airflow is not reduced due to the inadequate location of hatchers blocking the airflow.

Old hatchers using metal trays should be upgraded to plastic systems to avoid the radiation effect of the metal.

New hatchery designs always have better cooling systems. Observing bigger, corrugated serpentines and double entry for cooling water is common.

Existing hatchers can also be adapted to improve cooling capacity by using new serpentine designs or adding serpentines.

Preventive maintenance

Improving hatchability depends a lot on setter and hatcher maintenance **to double-check the following aspects:**

- Machine temperature set points are obtained uniformly in the whole machine
- Turning mechanisms work and reach the optimum 45o angles in all sections of the setter
- The static pressures in the hatchery rooms are adequate to maintain airflow.
- The water pressure in the lines and cooling nozzles are adequate
- The fan velocity is still optimum to maintain airflow
- The voltage and amperage charges are optimum

Conclusions

Hatchability depends on biological factors that must be understood.

The management of the egg and incubator machine must be adapted to the characteristics of each egg to maximize its hatchability.

Machines play an essential role in providing optimum environmental conditions to embryos. **Preventive maintenance is necessary to verify that machines consistently achieve the expected parameters in all their internal sections.**

Identifying and minimizing microenvironments is essential to reduce variability and avoid overheating. Good personnel training and data analysis are necessary to reach these goals.

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Thank you!

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