

Balancing the eggs

By Ron Meijerhof

Introduction.

The development of the embryo is determined by the temperature inside the shell, the so-called embryo temperature. This temperature will dictate the development, but with that also the hatchability and the quality of the day-old chick.

It is often assumed that this temperature is fully dependent on the temperature of the air.

Although temperature has a large influence on it, it is not the only factor and in some situations not even the most important factor to consider.

We want to keep the embryo temperature at a level of 100.0 to 100.5°F. This temperature inside the egg is the result of a balance between the heat production of the embryo on one side and the heat loss of the egg towards its environment on the other side.

One side of the balance: heat production

During development, the embryo produces metabolic heat. This heat production depends on the moment of incubation. At start of incubation, the heat production hardly exists. The first signs of heat production can be observed around day 4. From day 8-9 onwards the heat production becomes so high that the embryo temperature will rise if we don't react on it. At day 18, the heat production is at its highest level. Once the embryo's starts to pip the heat production rises again, due to the increased activity.

Not every breed produces the same amount of heat at a given moment in incubation. Broilers produce more heat than layer type birds, high-yielding breeds produce more heat than classical breeds, male lines do normally produce more heat than female lines and within one line males produce more heat than females.

Although there are differences in breeds, the effect of a higher embryo temperature is not equal for all breeds and lines. For instance layer breeds produce less heat than broiler breeds and therefore the embryo temperature will increase less, but the effect of 1 degree increase in layer breeds is much more dramatic than for broiler breeds.

The other side: heat loss

To keep the embryo temperature at the desired level of 100.0-100.5°F, we have to remove enough heat from the shell to compensate for the heat production. There are in principle four factors that influence the heat loss.

- Air temperature

A difference in temperature between shell and air will force the heat to flow either towards the shell (when air is warmer than shell) or from the shell (when shell is warmer than air). The bigger the difference in temperature is, the more heat will be transferred.

- Humidity

Humidity influences heat loss in two different ways.

Dry air can contain very little heat in itself. It is actually the water molecules in the air that carry the heat. We call this heat capacity: when more water molecules are present in the air (high humidity), more energy is stored per unit of air. This means that at a given temperature difference, humid air will remove more heat from the egg. As we normally incubate in a narrow range of humidity, this is not a major factor of importance. However, if we incubate at high altitude (low pressure), there are less water molecules in the air,

even at the same relative humidity as at low altitude, and the heat loss of eggs will be more difficult.

Eggs evaporate water at a constant rate, to a total of 12 to 14% of their initial weight. This evaporation of water costs energy, and moisture loss will therefore reduce egg temperature. When relative humidity is high, less water is evaporated and less heat will be lost.

These two mechanisms work in opposite directions: A high relative humidity will increase heat loss through increasing heat capacity but at the same time decrease heat loss through decreasing evaporation.

- **Air velocity**
A major factor in heat loss is air velocity. At the same temperature difference, objects will lose more heat if air velocity is high. We know that and use that very effectively in broilers, when we apply tunnel ventilation. It is also known in humans, where we call it the “wind chill factor”. For eggs this is exactly the same. Eggs in incubators that experience a high air velocity will lose more heat and therefore be colder than eggs at low air velocity. The difference can be as high as 2-3°F in embryo temperature at the end of incubation. This implicates that if air velocity differs between different spots in machines, the embryo temperature will vary, no matter how uniform the air temperature is. As racks and trolleys of eggs are blocking air velocity in a machine and air takes the way of the least resistance, it is easy to imagine that huge air velocity differences can sometimes be observed in commercial machines.
- **Water spray**
When the air in the machine is too dry, the machine will add water to compensate. As water needs energy to evaporate, this will cool the eggs that are close to this water spray. Although water evaporation has a cooling effect by itself and sometimes can be used to cool eggs, spraying huge amounts of water will decrease uniformity in embryo temperature, as usually the water is sprayed locally, and at places where there is already a high air velocity.

Practical implications

In the last decade, there has been done a lot of research in this area. By now we know that embryo temperature in commercial setters and hatchers is often quite variable, mainly due to differences in air velocity. This raises two questions:

1. Is it of practical importance, in other words, does it affect the embryo or the chick.
2. If it is important, can we do anything about it.

To answer the first question, yes, it is a very relevant factor affecting both hatch and chick performance. Practical experience shows that controlling embryo temperatures between acceptable ranges can result in a better hatchability and especially a better chick quality. Especially the influence on yolk uptake and closure of the navels is high, resulting in differences in first week mortality due to navel/yolk sac infections and e-coli infections. Research has shown that differences in embryo temperature away from the optimum result in a significant difference in hatchability, but also in growth and feed conversion of broilers at 6 weeks of age. Also the development of the total embryo as well as specific organs like the heart muscle are influenced, resulting in for instance a difference in ascites susceptibility.

The second question is more difficult to answer. With a single stage machine, we can at least adjust the machine temperature to match the heat production of the embryo. Although this gives an explicit and nowadays well recognised benefit over multi-stage machines and will result in a better chick quality, not all single stage machines are equal.

Because the major important factor for embryo temperature is air velocity and to a lesser extent the place and function of the humidifier, a substantial part of the problem is in the design of incubators and hatchers, which is challenging incubator manufacturers. Only by creating an equal air velocity over all egg and avoiding local evaporation of water, a uniform embryo temperature can be achieved. Without control on these points, the laws of physics simply don't allow a uniform embryo temperature and with it a uniform and optimal development of the embryos.

Although a lot can be done to improve the uniformity and control of embryo temperature in existing machines, the fundamental issue has to be solved in the designing stage of new machines. A simple check on the uniformity in embryo temperature of 18 day incubated eggs at different spots in the machine will show how well the design of a machine handles the factors that influence heat loss of the eggs.

Incubators that provide a uniform embryo temperature will allow us to create a more optimal environment for all the developing embryos, resulting in a better hatchability, a better chick quality and a better bird performance.