CO_2 and the miracles of nature

By Ron Meijerhof

As everybody who works with hatching eggs will admit, eggs are little wonders of nature. The physiology that makes it possible to change an egg into a living chicken in 3 weeks time are so complex that we most likely will never really understand the systems behind it. But, over the years we have learned more and more.

Protection against micro-organisms

One of these fascinating mechanisms is the way eggs protect themselves against invasive micro-organisms. In the hen's body, the egg content has the carbon dioxide (CO_2) concentration and the pH level of the blood of the hen. Once the egg is laid, the carbon dioxide escapes through the egg shell, which increases the pH of the albumen in a few days from the initial level of 7.3 to 9.3 and higher.

At this high pH level, it is impossible for bacteria to enter the egg. But it is questionable, whether this high pH is optimal for embryonic development. Measurements in embryos after the first hours/days of incubation show that their internal pH is approximately 8.3-8.5, so a lot lower than the level the egg uses to protect itself against bacteria.

CO_2 management in the egg

But how does the embryo/egg manage to get a pH of 8.3 in the albumen after incubation has started? Probably by simply producing CO_2 itself. When the temperature of the embryo increases, it starts to develop. The by-product of this metabolism is CO_2, and this CO_2 will lower the pH in the first layer of the albumen surrounding the embryo, creating a "shell" of optimum pH for embryo development, while the rest of the egg is still protected against bacteria.

An embryo in a short stored egg is able to form a barrier between itself and the surrounding, as it is able to produce enough CO_2 to form an effective shell of optimum pH. However, an embryo in a long stored egg cannot produce enough CO_2 to optimise its micro environment, as it is weaker after the prolonged storage period. On top of that, eggs from older flocks and eggs that are stored for longer periods have poor albumen quality, which will allow the formed CO_2 to move away from the embryo faster.

How to support the embryo

To create an optimum environment for especially the long stored embryo, we must prevent the CO_2 from moving away from the embryo too quickly.

By closing the incubator completely for the first few days of incubation, we keep all the CO_2 produced by the embryo in the machine, which slows down the escape of CO_2 through the albumen and the egg shell. However, the production of CO_2 by the embryos is rather low during the first days of incubation, especially if eggs are stored for longer times or have a low fertility.

By artificially adding CO_2 in the incubator, we can help the embryos much more sufficiently. Research and field experiences have shown that adding CO_2 to a level of 5000-7000 ppm for the first 3 to 5 days of incubation increases the hatching results and especially chick quality when storage times are extended beyond 7-10 days.

Additional effects of adding CO_2?
Manipulating the pH level during the first few days of incubation might reduce early embryonic mortality, because weaker embryos are able to survive, but this is not the only positive effect. It also influences late embryonic mortality and chick quality. Research suggest that adding CO_2 in the first days of incubation is also beneficial for blood vessel development in the embryo, which will increase the oxygen availability for the embryos in the later stages of incubation. This added effect might explain the difference that we have observed in late embryonic mortality and chick quality.

How to use in the field?
Increasing the CO_2 levels in an incubator is not so difficult. Keeping the machines closed will keep the produced CO_2 inside, and a bottle of liquid CO_2 can provide any necessary CO_2 needed at relatively low costs.
The first requirement for CO2 control is a gas sealed incubator. When an incubator is not gas sealed, keeping an increased level of CO_2 will become a real challenge. Many incubators in the field have a so-called half time of less than an hour. This means that if CO_2 is injected to bring up the level to 7000 ppm, within an hour enough CO2 has escaped to reduce the level to 3500 ppm, half of the initial value. If incubators are not gas sealed, it is clear that injecting CO2 to maintain a level of approximately 7000 ppm will be a more or less continuous process that requires high amounts of CO2.
But even very well sealed incubators show some minor leakage. In a very well closed incubator, it will take approximately 6 to 10 hours before an initial CO_2 level of 7000 ppm is reduced to 3500 ppm, but this still requires a more or less regular adding of CO_2 to maintain sufficient levels.