Activated vitamin D: Connecting parents and offspring

Good chick quality and the number of fertile settable eggs per hen housed are the main drivers in broiler breeder operations. Apart from incubation conditions, successful hatchability depends on many factors related to eggshell quality (for example strength, porosity and absence of microfractures).

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As in laying hens, eggshell quality is a concern in broiler breeders, especially towards the end of production. Too thin eggshells allow higher loss of water during incubation, resulting in dehydrated chicks, higher risk for bacterial infections and increased embryonic mortality. In addition, thin eggshells crack easily during collection and transport, resulting in reduced hatchability.

Poor eggshell quality has been linked to a reduction of calcium (Ca) absorption with increasing hen age, which nutritionists usually try to compensate by increasing dietary limestone inclusion.

Recent research showed that the reduced Ca absorption with age is caused by the reduced efficiency to activate vitamin D into its bio-active form 1,25-dihydroxycholecalciferol (1,25(OH)2D3) in the kidneys. Besides age, also mycotoxins, metabolic disorders in liver and kidneys and stress can negatively affect Ca metabolism.

Fertility of breeder flocks also tends to decrease with age. In the 80s, the potential of direct vitamin D action on the ovary was suggested for the first time. As the female gonad, the ovary is responsible for steroid hormone production to maintain endocrine function and generating competent oocytes for fertilisation.

Vitamin D deficient hens have reduced levels of serum follicle stimulating hormone (FSH) as well as of luteinising hormone (LH). FSH regulates the follicular development and growth, and reproductive processes whereas LH initiates ovulation in females and stimulates production of testosterone by Leydig cells in males.

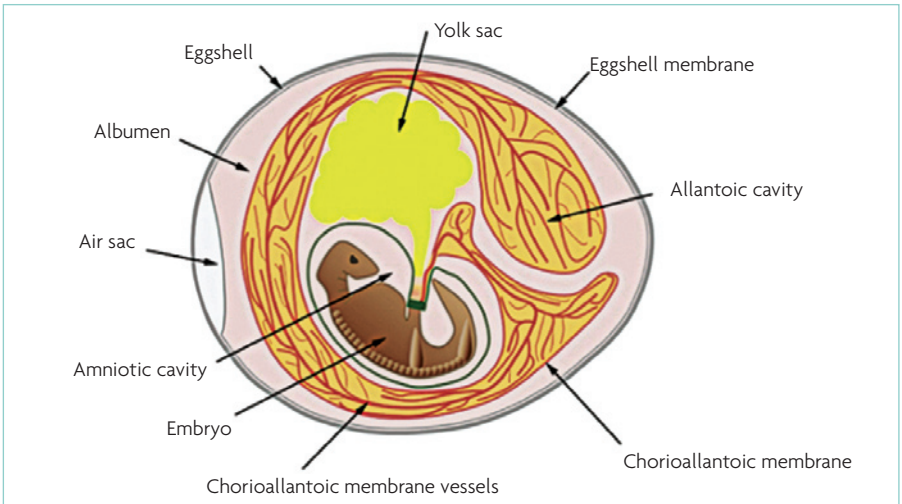


Fig. 1. Fertilised egg showing embryo and the supporting extra-embryonic membranes (Choriallantoic membrane (CAM), yolk sac, and amnion). The CAM is a highly vascularised membrane, which is connected to the embryo (Source: Ahmed et al, 2022).

Furthermore, the size and weight of the oviduct and the vascularisation of the follicles are correlated with vitamin D levels in hens. However, the mode of action of vitamin D on fertility and reproductive traits in avian species needs further research.

1,25(OH)2D3 and embryo development

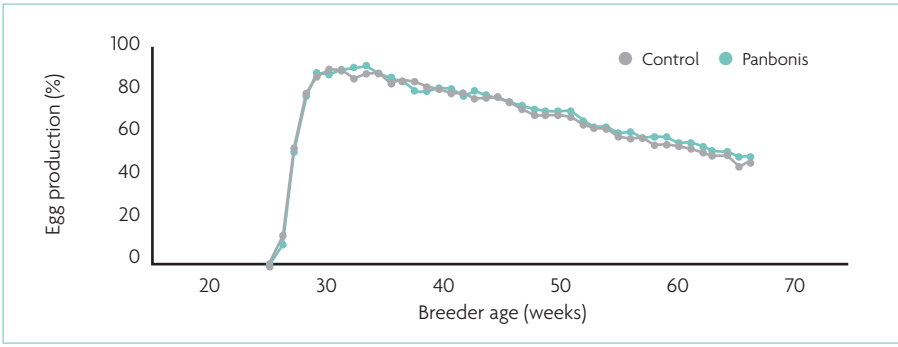
During embryo development, Ca is mobilised from two extra-embryonic sources, initially from the yolk and later from the eggshell.

The yolk is the only source of nutrients for the embryo during incubation and the amount of Ca transported to the yolk before ovulation is highly dependent on the levels of vitamin D in maternal diets.

As the developing embryo requires substantial amounts of Ca for skeletal growth, Ca is also released from the eggshell and transported to the developing embryo. The chorioallantoic membrane (CAM) is responsible for mobilising 80% of eggshell Ca via the enzyme carbonic anhydrase.

The secretion of this enzyme is stimulated by 1,25(OH)2D3.

Fig. 2. Hen day production curve (%) of the control and test group.



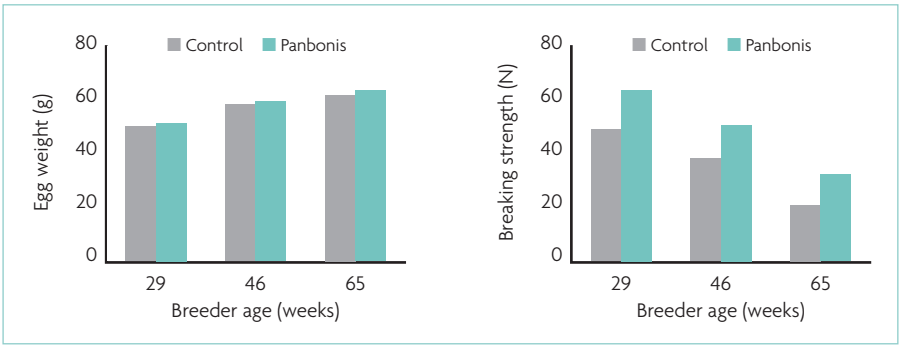


Fig. 3. Egg weight and eggshell breaking strength of the control and test hens at different ages.

Moreover, also the successive transport of the released Ca to the embryo across the CAM is mediated by 1,25(OH)$_2$D$_3$. However, the mode of action is still unknown.

Solanum glaucophyllum naturally contains 1,25(OH)$_2$D$_3$-glycosides

Supporting the vitamin D metabolism to improve Ca homeostasis, eggshell quality and reproductive traits in parent stock is a better approach than just supplying extra dietary limestone. Due to the reduced level of 1,25(OH)$_2$D$_3$ with increasing age, the efficiency of absorption of dietary Ca is limited and therefore extra dietary limestone will only partially solve this age effect on eggshell quality.

Moreover, non-absorbed Ca will impair the digestibility of other nutrients.

A way to support the vitamin D metabolism is by supplementing the diet with Solanum glaucophyllum, one of the few plants that naturally contains the active metabolite of vitamin D in a glycosidic form (G-1,25(OH)$_2$D$_3$).

G-1,25(OH)$_2$D$_3$ compensates for the limited activation of vitamin D (age, stress, mycotoxins, reduced activity of hepatic and renal enzymes), acts fast and is a good option to support birds in periods with increased 1,25(OH)$_2$D$_3$ demand.

To show the benefit of G-1,25(OH)$_2$D$_3$ in broiler breeders, a trial was carried out with 5,350 Ross 308 parent birds, distributed in two barns in Brazil. Breeders were fed a commercial diet with and without 1µg G-1,25(OH)$_2$D$_3$ (as Panbonis, Herbonis Animal Health, Switzerland) from 24 weeks of age until the end of the production at 64 weeks. Eggs were collected at 29, 45 and 60 weeks of age to measure egg weight and shell quality. At weeks 46 and 62 hatchability and saleable hatch were measured.

Egg production during the entire production period was on average 1.9% higher in the Panbonis treatment group (184.3 vs. 180.8 eggs) (Fig. 2).

Eggs from hens supplemented with Panbonis were in general 1.4% heavier (65.0 vs. 64.1g) and had 3% higher breaking strength (31.6 vs. 30.1N) than those from the control birds (Fig. 3), resulting in 4.8% less broken and 17% less defective eggs.

Moreover, the egg specific gravity, an indicator of shell weight relative to other egg components and thus a parameter for eggshell quality, was measured. In accordance with the deterioration of the eggshell quality with age, also egg specific gravity usually reduces with the age of the hen.

Eggs should have a minimal specific gravity of 1.080. Embryo mortality below this threshold value increases and hatchability reduces. In line with the improved breaking strength, also egg specific gravity was increased in the hens supplemented with Panbonis at all time points (Fig. 4).

The hatchability and % saleable hatch from 4,500 sampled eggs in the control and supplemented birds were similar at 46 weeks of age and higher in 62 weeks old breeders supplemented with Panbonis (Hatchability: Panbonis 70.8% vs. Control 66.7%; Saleable hatch: Panbonis 68.3% vs. Control 64.2%).

Considering egg production and increased hatchability, Panbonis supplementation resulted in 4.8 chicks extra per hen housed. Egg fertility depends mainly on the age of the bird. At week 46, both groups had an average fertility of 93.0%, whereas the reduction with age was smaller in the Panbonis supplemented birds compared to control birds (80.0% vs. 75.4%, respectively). This confirms the role of 1,25(OH)$_2$D$_3$ on fertility as previously indicated, being more pronounced with age.

One-day old chick weight

In this trial, eggs were hatched per treatment and male chicks were used for the evaluation of one-day old chick weight. As expected, the one-day old chick weight was increased with breeder flock age. At the same time, chicks hatched from breeders supplemented with Panbonis were heavier at hatch than those from control breeder flocks (Fig. 5).

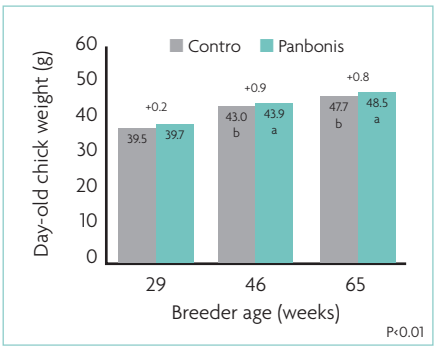


Fig. 5. One-day old chick weight from breeders supplemented with or without Panbonis.

It was concluded that the supplementation of broiler breeder diets with Panbonis improved their reproductive performance, egg quality and improved offspring weight and quality. ■

Fig. 4. Egg specific gravity of hens at 30, 46 and 62 weeks of age.