# The effect of laying hen nutrition on egg quality

**by Fabien Galea, nutritionist, technical manager, ISA.**

Egg quality is an important parameter which will affect the income of all sectors within the egg industry.

Hatcheries, egg producers and egg processing plants will not give the same definition of egg quality, but important components of egg quality include egg shell quality (strength and cleanness), nutritional egg composition, egg size, and vitelline membrane strength. Nutritional factors are involved in most of the egg quality components.

Many nutritional factors have been reported to have an effect on eggshell quality. These factors can be sorted into two classes – direct factors, which have a strong effect on eggshell quality, and indirect factors, which have an effect on egg size and indirectly on eggshell quality.

## Direct effects on eggshell

As laying hens get older, egg size increases. However, the eggshell percentage compared to the egg size decreases. Eggs are bigger but with a lower eggshell percentage so the total calcium exported through the egg increases. This leads to a higher calcium requirement for older hens. Calcium deficiency will lead to a weaker eggshell with a decrease of eggshell weight and eggshell strength.

Calcium particle size is probably the most important parameter which affects eggshell quality. Most calcium particles below 2mm are found in the manure, unlike particles above 2mm which are retained in the gizzard. Calcium particles stored in the gizzard will slowly solubilise, delaying the calcium assimilation.

Eggshell formation takes 12-14 hours and occurs mainly during the night, which is when most calcium is required. Bones are the calcium storage organs and more precisely medullary bone. Several trials have shown eggshell is stronger if the calcium is coming from the feed instead of the bone.

Providing a high amount of large calcium particle size before the night will help laying hens to produce strong eggshells.

Interaction with management practices is strong. According to the limestone source, solubility may be different. Calcium with a high solubility will be not stored for a long time in the gizzard, cancelling the particle size effect.

Phosphorus is an important nutrient for eggshell quality. Phosphorus has a strong effect on bone strength. Calcium and phosphorus are combined in the hydroxyapatite crystal and stored in the bones. If calcium provided from the feed is not enough to support the calcium requirement for eggshell formation, calcium is mobilised from the bones. However, this calcium mobilisation is linked with a phosphorus release in the blood.

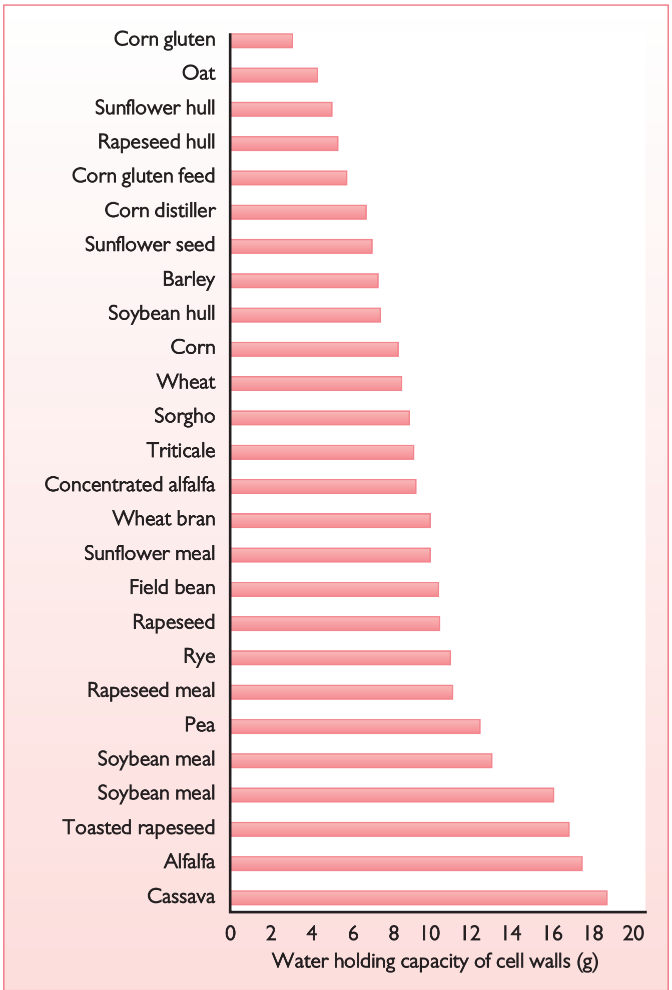
A high phosphorus level in the blood inhibits the calcium mobilisation from the bones. Several trials have shown a negative correlation between the phosphorus content of the diets and the eggshell quality.

A high phosphorus intake leads to increased phosphorus content of the blood, which inhibits the bone calcium mobilisation and then eggshell quality is depressed.

Phosphorus is required for strong bones but high levels depress eggshell quality.

Vitamin D is necessary for calcium metabolism. Vitamin D deficiency leads to poor eggshell quality, mainly due to a decrease in the weight of the eggshell. Trace elements like zinc, copper and manganese have been shown to have an effect on eggshell quality. They influence calcite crystal growth during eggshell formation and influence the mechanical propriety of eggshell.

***Fig. 1. Cell wall water holding capacity of different raw materials (from Carré et al 1995).***




## Indirect effects on eggshell

Some nutritional factors have an indirect effect on eggshell quality. Indirect effects could be through egg size management or liver protection.

Smaller eggs have a better eggshell strength. Diets rich in fat, in unsaturated fatty acid, like linoleic acid, with high levels of protein and amino acids, increase the egg size. These factors must be considered when eggshell quality issues occur.

Liver is the key organ for egg production. Egg yolk is synthesised in the liver and then transported to the follicles. The liver is also the place where the first vitamin D hydroxylation occurs.

Vitamin D needs two hydroxylations before being efficient for calcium transportation. Laying hens suffering from fatty liver produce less eggs and eggs with bad eggshell quality. All the nutritional factors which help to protect the liver, like choline, folic acid and vitamin B 12, also have an indirect effect on eggshell quality by preventing the liver's ability to convert vitamin D.

## Egg shell cleanliness

Eggshell cleanliness depends on water consumption, manure structure, manure water holding capacity and interaction between each other. Most of these parameters are linked with nutrients.

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Water consumption is influenced by electrolyte levels in the diet, mostly sodium, potassium and chlorine, and the balance between all of them. Other electrolytes, like sulphur, magnesium and calcium, could also have an effect, but a minor one.

Soluble fibres, like xylan, β-glucan and pectic substances, increase water consumption. These elements increase gut viscosity. To fight against this effect, birds increase their water consumption. The use of enzymes (xylanase/β-glucanase) has been shown to decrease the negative effect of soluble fibre by decreasing water consumption.

Insoluble fibres, like cellulose, hemi-cellulose and lignin, are not digested by poultry and therefore give structure to the manure.

Fibres, soluble and insoluble, give physical proprieties to excreta by influencing their water holding capacity. Raw materials contain different fibre profiles and have an impact on the water holding capacity of manure.

The water holding capacity and sticky proprieties of manure are linked and have an impact on dirty eggs.

Other raw materials like clays have been shown to decrease dirty eggs. Clays have a high water holding capacity. According to the type of clay (bentonite/sepiolite), water holding capacity differs. The addition of clay to layer diet decreases the percentage of dirty eggs.

## Egg white quality

Nutritional factors can also affect egg white quality. Egg white composition is strongly linked to the diets used.

The concentration of vitamins in feed, and mainly water soluble vitamins, has been shown to affect vitamin egg white concentration.

Riboflavin, folic acids, niacin, thiamine, pyridoxine, pantothenic acid, biotin and vitamin B12 are well transferred into the egg white and their concentration depends on feed concentration.

Trace elements are also well transferred into the egg white. Egg white concentration of iodine, selenium and copper are linked to the levels used in the feed.

Blood spots found in the egg white could have some nutritional links. Blood spots are affected by contamination by mycotoxins, like ochratoxin, strong choline deficiency, or vitamin A and vitamin K.

## Egg yolk quality

Egg yolk composition strongly reflects the feed composition. The egg yolk fatty acid profile is directly linked to the fatty acid profile of diets. Diets rich in omega 3 fatty acids lead to egg yolk rich in omega 3 fatty acids. The same observations have been made for the omega 6 fatty acids. Fatty acids found in the egg yolk are linked to the fatty acid profile of the feed.

The concentration of vitamins in the feed also affects egg yolk vitamin composition. Compared to the egg white, where water soluble vitamins are well transferred, the egg yolk, due to its composition, contains mainly fat soluble vitamins, which are transferred, like vitamin A, vitamin E and vitamin D.

Water soluble vitamins have also been reported to be transferred in the egg yolk: riboflavin, folic acids, niacin, thiamine, pyridoxine, pantothenic acid, biotin and vitamin B12. The proportion of these water soluble vitamins transferred in the egg yolk is higher.

Feed trace elements concentration directly affects the egg yolk composition. Good transfer rates have been shown for iodine, copper and selenium. Some differences have been observed according to the trace element source. Organic forms have a better transfer than inorganic forms.

Many carotenoids are transferred to the egg yolk (canthaxanthin, citranaxanthin, apo carotene ester, lutein, zeaxanthin). Egg yolk concentration is directly linked to feed concentration. Transfer efficiency is not the same according to carotenoids.

Carotenoids bring colour to the egg yolk, which is important for consumers, but also modulate the antioxidant potential of the eggs.

The antioxidant concentration affects human heath and/or the embryo development.

***Table 1. Vitamin concentration of eggs with classical and enriched diets (Leeson and Caston, 2003).***

| Vitamin | Regular eggs (µg/60g eggs) | Modified eggs (µg/60g eggs) |
|---|---|---|
| Vitamin A | 59 ± 25 | 75 ± 2 |
| Vitamin D3 | 0.39 ± 0.03 | 1.14 ± 0.005 |
| Vitamin E | 1320 ± 80 | 3760 ± 260 |
| Vitamin E | 130± 3 | 130 ± 1 |
| Thiamin | 49 ± 1 | 67 ± 2 |
| Riboflavin | 219 ± 31 | 245 ± 36 |
| Pyridoxine | 27 ± 2 | 33 ± 3 |
| Biotin | 17 ± 2 | 18 ± 0.5 |
| Folic acid | 9 ± 0.00 | 10 ± 0.00 |
| Niacin | 47 ± 6 | 77 ± 33 |
| Pantothenic acid | 763 ± 165 | 1205 ± 183 |
| Vitamin B12 | 0.87 ± 0.04 | 3.35 ± 0.11 |

## Vitelline membrane

One important parameter for the egg processing plant is the strength of the vitelline membrane. A strong membrane is useful to easily separate the white and the yolk. A weak membrane leads to important economical losses because once the membrane is broken, the egg yolk will pollute the egg white.

Like the egg yolk, the vitelline membrane fatty acid profile depends on the fatty acid profile of the feed. The type of fat used in the feed affects the fatty acids incorporated in the vitelline membrane. Elasticity and permeability of the membrane are then affected. Saturated fatty acids increase vitelline membrane permeability. Vitamin E has been shown to increase vitelline membrane strength. This effect is stronger at 34°C than 21°C.

As we have seen, egg composition and egg quality directly and indirectly reflects feed composition.

Feed composition has to be adjusted according to the egg quality required by the different players within the egg sector and according to feedback from the field. ■

*References are available from the author on request*