Nutrition and food management and their influence on egg quality

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ABSTRACT

Egg quality can be easily adjusted by feed composition. Several nutrients have an effect on egg quality and have to be considered to adjust egg quality to requirements of the different egg business players. Calcium levels, calcium particle size, calcium source solubility, phosphorus and vitamin D have a direct effect on eggshell quality. Total fat, feed fatty acid profile, choline, folic acid and vitamin B12 are also indirectly affecting eggshell quality. Feed distribution management have a strong effect on eggshell quality. Dirty eggs are linked to water consumption, manure structure and water holding capacity. Electrolytes like sodium, potassium, chlorine and the electrolyte balance affect water consumption. Soluble fiber increase water consumption but appropriate enzyme use can decrease this negative effect. Raw material fibers have different water holding capacity and affect proportion of dirty eggs. Clay utilisation in feed can help to control manure quality and indirectly dirty eggs. Feed distribution during the lay increase dirty eggs proportion. Egg white composition is linked to water soluble vitamins and some trace elements concentration in feed. Blood spots are linked to vitamin A, vitamin K, ochratoxin and choline concentration. Egg yolk fatty acid composition is strongly influence by feed fatty acid profile. Egg yolk vitamins, trace elements and carotenoids concentration could be adjusted according to the feed concentration. Vitelline membrane fatty acid profile is linked to feed fatty acid profile. Vitelline membrane strength is related to vitamin E concentration mainly in hot weather condition.

There is a strong impact of feed management in the farm with egg composition. Empty feeder technics, feed distribution schedule, flock evenness, feed particles size need to be controlled to obtained uniform feed and nutrients consumption and even egg quality.

Keywords*: vitamin, trace element, fatty acid profile, vitelline membrane, egg yolk, egg white, eggshell, dirty eggs, management, calcium, phosphorus, fiber.*

INTRODUCTION

Egg quality definition is not the same according to the different player of the egg industry, but for all of them egg quality is an important parameter which will affect incomes. Hatcheries, egg producers, egg processing plants do not give the same definition of egg quality. Important components of egg quality are egg shell quality (strength and cleanness), nutritional egg composition, egg size, vitelline membrane strength, etc… Nutritional factors are involved in most of the egg quality components and management as well. What affects egg quality is not only the feed composition but the way birds are feed.

EGG SHELL QUALITY

Many nutrional factors have been reported to have an effect on eggshell quality. These factors could be sorted in 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.

Nutrional factors with direct effect on eggshell quality

As laying hens get older, egg size increase. But the eggshell percentage compare to the egg size decrease. Eggs are bigger but with a lower eggshell percentage but total calcium exported through the egg increase. This leads mechanically to higher calcium requirement for older hens. Calcium deficiency will lead to weaker eggshell with a decrease of eggshell weight and eggshell strength (Bar et al 2002).

Calcium particle size is probably the most important parameter which affects eggshell quality. Most of calcium particle below than 2mm are found in the manure, unlike particle above 2mm which are retained in the gizzard (Rao et Rolland 1989). Calcium particle store in the gizzard will slowly solubilise, delaying the calcium assimilation. Eggshell formation takes 12 to 14 hours and occurs mainly during the night period. Most of the calcium required for eggshell formation is during the night. 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 (Keshavarz 1998). Providing a high amount of large calcium particle size before the night will help laying hens to produce strong eggshell (Keshavarz 1998). Interaction with management practices is strong.

According to the limestone source, solubility may be different. Calcium with a high solubility will be not store for a long time in the gizzard, cancelling the particle size effect (Zhang and Coon 1997).

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, storage form of calcium and phosphorus in the bones. If calcium provide from the feed is not enough to support the calcium requirement for the eggshell formation, calcium is mobilize from the bone. But this calcium mobilisation is link 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 (Miles et al 1983). A high phosphorus intake leads to increase the phosphorus content of the blood, which inhibits the bone calcium mobilization. Then eggshell quality is depressed. Phosphorus is required for strong bones but high levels depressed eggshell quality.

Vitamin D is necessary for calcium metabolism. Vitamin D deficiency leads to poor eggshell quality, mainly due to a decrease of the eggshell weight (ref).

Trace elements like zinc, copper and manganese have shown to have an effect on eggshell quality. They are influencing calcite crystal growth during the eggshell formation and influencing mechanical propriety of eggshell. (Mabe et al 2003).

Nutrional factors with indirect effect on eggshell quality

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

Smaller eggs have a better eggshell strength. Diets rich in fat (Antar 2004), in unsaturated fatty acid like linoleic acid (Grosbas et al 1999), with high levels of protein and amino acids, push up the egg size. These factors must be considered when eggshell quality issues happened.

Liver is the key organ for egg production. Egg yolk is synthesised in the liver and after transported to the follicles. But liver is also the place where the first vitamin D hydroxylation occurred. Vitamin D needs two hydroxylations before being efficient for calcium transportation. Laying hens suffering of fatty liver produced less eggs and eggs with a bad eggshell quality. All the nutritional factors which help to protect the liver, like choline, folic acid and vitamin B 12 (Griffith 1969) have also an indirect effect on eggshell quality by preventing the liver ability to convert vitamin D.

Eggshell quality and management interaction

As we have seen above, diet composition is a crucial point for obtaining good eggshell quality. But what is more important is the amount of nutrients intake and the moment when these nutrients are available for the hens. Eggshell formation occurred mainly during the night when birds are sleeping. The management key point is to use all technics to improve calcium consumption before or during the night. Most of the feed has to be provided the afternoon and before the night to fill the crop. In some country where it is allowed, midnight feeding could be very help full too. Then calcium will be slowly solubilised during the night and will minimize calcium provided from the bones, leading to good eggshell quality. Empty feeders must be obtained once a day around noon to avoid particle sorting and to promote fine particles consumption.

Cleanness of egg shell

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

Water consumption is influenced by electrolytes levels in the diet, mostly sodium, potassium and chlorine, and the balance between all of them. Other electrolytes like sulphur, magnesium, calcium could have an effect also, but a minor one (Smith et al 2000).

Soluble fibers, like xylan, βglucan and pectic substances, increase water consumption. These elements increase gut viscosity (Choct 1997). For fighting against this effect, birds increase water consumption. Use of enzymes (xylanase / βglucanase) has been shown to decrease negative effect of soluble fiber by decreasing water consumption (Engberg 2004).

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

Fibers, soluble and insoluble, give physical proprieties to excreta by influencing their water holding capacity. Raw materials contain different fiber profile and have an impact on the water holding capacity of manure (Carré et al 1995). Water holding capacity and sticky proprieties of manure are linked and have an impact on dirty eggs.

Other raw materials like clays have be shown to decrease dirty eggs. Clays have a high water holding capacity. According to the type of clay (bentonite / sepiolite /etc…), water holding capacity differs. Clay addition to layer diet decreases dirty eggs percentage (Ouhida 2000).

Dirty eggs and management interaction

The simple management rule to respect to decrease dirty egg is : do not feed the birds during the laying period. When birds are eating, the natural behaviour is to produce droppings at the same time. Then manure makes dirty the cage bottom and increase the risk to obtained dirty eggs. Feeding birds during the laying period could lead also to dirty cloaca which could increase total amount of dirty eggs.

EGG WHITE QUALITY

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

Feed vitamins concentration, and mainly water soluble vitamins, has been shown to affect vitamin egg white concentration. Riboflavin , folic acids, niacin, thiamine, pyridoxine, panthotenic acid, biotin, vitamin B12 are well transferred into the egg white and their concentrations depend on feed concentration (Leeson and Caston 2003, House 2002).

Trace elements are also well transferred into the egg white. Egg white concentration of iodine (Yalcin 2001), selenium (Surai and Dvorska, 2001) and copper (Idowu 2006) are linked to the levels used into the feed.

Blood spots found into the egg weight could have some nutritional links. Blood spots are affected by mycotoxins contamination like ochratoxin (Shirley and Tohala 1983), strong choline deficiency, vitamin A (Bearse et al 1960) and vitamin K (Berruti and Didrick, 1961).

EGG YOLK QUALITY

Egg yolk composition strongly reflects feed composition.

Egg yolk fatty acid profile is directly linked to the fatty acid profile of diets. Diets rich in omega 3 lead to egg yolk rich in omega 3. Same observations have been made for the omega 6 fatty acids. Fatty acids found in the egg yolk are linked to the feed fatty acid profile (Leeson et Calson 1990).

Feed vitamins concentration affect also egg yolk vitamin composition. Compare to the egg white, where water soluble vitamins are well transferred, for egg yolk due to its composition, it is mainly fat soluble vitamins which are transferred like vitamin A, vitamin E and vitamin D (Leeson and Caston 2003). Water soluble vitamins are also been reported to be transferred in the egg yolk : riboflavin, folic acids, niacin, thiamine, pyridoxine, panthotenic acid, biotin and vitamin B12 (Leeson and Caston 2003, House 2002). The proportion of these water soluble vitamins transferred in the egg yolk is higher.

Feed trace elements concentration affects directly 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 (Yalcin 2001, Surai and Dvorska, 2001, Idowu 2006).

Many carotenoids are transferred to the egg yolk (canthaxanthine, citranaxanthine, apo carotene ester, lutein, zeaxanthine,etc...) (Surai 2003, Steinberg 2000, Steinberg 2001). Egg yolk concentration is directly linked with feed concentration. Transfer efficiency is not the same according to carotenoids. Carotenoids bring colour to the egg, yolk which is important for consumers, but modulate the anti-oxidant potential of the eggs too. Antioxydant concentration affects human heath and/or the embryo development.

Vitelline membrane

One important parameter for egg processing plant is the vitelline membrane strength. A strong membrane is useful to separate easily white and yolk. Weak membrane leads to important economical loses because once the membrane is broken, egg yolk is polluting the egg white.

Like the egg yolk, vitelline membrane fatty acid profile depends on feed fatty acid profile. Type of fat in the feed used affects fatty acids incorporated in the vitelline membrane (Watkins 2003). Elasticity and permeability of the membrane are then affected. Saturated fatty acid increases vitelline membrane permeability (Aydin 2001).

Vitamin E has been shown to increase vitelline membrane strength. This effect was stronger at 34°c compare to 21°c (Kirunda 2001).

Considering vitelline membrane strength, strong interactions with bird and farm management exist. Older hens have weaker vitelline membrane. Eggs must be collected as soon as they are laid and must not stay a long time on the egg belt. Storage temperature and time are also affecting vitelline membrane strength.

Egg composition and management interaction

All nutritional factors affecting egg composition, whatever the egg part, are linked to nutrients intake. Nutrients intake is the nutrient composition multiplies by feed consumption. So, feed consumption is a crucial point to control to be sure to obtain desired eggs.

Focus must be done on feed distribution management. Laying hens are grain eater and have a strong preference for coarse feed particles. Feed distribution management must introduce an empty feeder period once a day, to secure fine particles consumption. We advice a empty feeder period around noon. The aim is to secure intake of small particles containing phosphate, vitamins, trace elements and pigments. When birds are sorting feed particles, eggs obtained are very variable in term of composition. Other factors like feeder space per hen, flock evenness, feed grist size has to be considered to obtain uniform feed consumption.

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