Egg Focus

9. Ventilation systems

by Lasse Kiel Madsen, Segment Manager Layer Industry, and Catherine Brynielsson, Marketing Manager, Munters.

The various egg production systems that are used all over the world create a need for flexible and reliable ventilation solutions. The one thing that should not be flexible or random is the cost of running that same ventilation system. Farmers and growers want to know that their system performs well, but also what the operation costs are.

Whether a layer farmer uses cages, enriched cages, barn, free range, aviary or organic production methods, the climate control system needs to properly ventilate every nook of the building. If there is a sudden cold spell, the system needs to be prepared for adding the right amount of heating power and a system for emergency opening when there is a power loss.

All of the above, coupled with sufficient feed and water access, makes the laying hens comfortable and healthy, which makes them produce better quality eggs and improves the number of hen days.

Munters take great pride in being able to deliver an energy efficient and well performing climate control system that fits any of the above mentioned production systems, and also with the objective for the farmer/grower to have as low Total Cost of Ownership (TOC) as possible to increase farm profit.

Choice of parameters

In most cases the production system has been chosen by the farmer which more or less decides the layout and design of the ventilation system. The next thing to take into consideration is the ambient climate condition of the specific location.

Average winter and summer temperatures and humidity levels as well as other specific weather types that the climate control system needs to be ready for are carefully collected and investigated. The control at the heart of the system will be configured so that it responds to changes in temperature, humidity and, for example, strong winds.

In a large hen house there are several design challenges and they are all more or less unique to every layer house, but it is possible to outline some general challenges.

Creating uniformity

One important challenge is to create uniformity, especially in an aviary free range production system. With the hens being free to move around the layer house, this is essential.

Uniformity means there can be no cold or warm spots in the house. If that occurs during cold periods, the hens will be clustered around warmer spots and there is a risk of disturbances, overload on the egg handling system or fighting in the flock. The same scenario of clustering will occur during warm periods if there are cold spots, likewise creating an imbalance in the house.

Uniformity always starts with placement of the climate equipment for an even distribution of fresh incoming air and taking stale air out of the house. The type of inlet chosen depends on the climate conditions where the house is located.

If the incoming air is cold for a period of the year, one generally wants to avoid that cold air drops down directly towards the birds, something which will inevitably disturb them and cause a non-uniform climate. For these cases, a horizontal and radial spread of air is desired which will mix with warmer air next to the attic or ceiling before it drops down on the flock.

In the design phase, attention also needs to be paid to the distance between the ceiling/attic air inlets so that the optimum air flow inside the building can be reached.

How do we know that we got it right? Well, there is no second chance; we have to design it correctly from the start. We know that it is working when we see that the birds are very uniformly spread.

It is not possible to go and clean the ventilation equipment during a cycle without considerably disturbing the animals and causing wet litter. Before the flock is replaced, the entire house including equipment can be hosed down with high-pressure cleaners and disinfectants. Munters equipment is made for environments that are both dirty and which contain high acidity levels.

Bedding quality

The second challenge for a climate control system is bedding quality, at least for free range production systems where birds move around on the floor. This typically consists of straw, wood shavings or sand.

The layer farmer wants the bedding material to remain dry so that it does not stick to the birds' feet and end up in the nests, thereby clinging to the egg shells and causing dirty eggs that the farmer will not get paid for. Wet bedding material mixed with manure will increase the ammonia levels inside the house, negatively affecting both animals and people. A well ventilated building with sufficient air flow and heating on a need basis will ensure that the bedding material is kept dry.

So there are advantages for the farmer when it comes to keeping the bedding material dry; and it all spells better farm economy and improved profits.

Floor eggs

The third challenge for the layer farmer concerns floor eggs and how to avoid them. It is a cumbersome job to collect these (several times per day) – man-hours that could be used for other jobs on the farm – and it could mean a lost income if the floor eggs get dirty.

There is something that can be done to prevent this from happening from a ventilation point of view. The ventilation design needs to make sure that there are no draughts in the nesting areas of the layer house. As long as the nesting area is a comfortable zone for the hens, this is where they will prefer to lay their eggs and this means that the egg handling system will take care of the product.

Light control

The fourth climate challenge for poultry farms is light control. Getting at least eight hours of sleep is crucial for layer hens. During summer, especially in the northern hemisphere, creating eight hours of darkness can be pretty challenging in itself. Pitch-black is not necessary but a brownout effect is.

Light spots on the floor or cages are something the farmer would want to avoid since it prevents the chickens from falling asleep. Light spots can be avoided by carefully designing the climate control system and choosing products which counteract light spots.

Drip pans underneath chimney fans and deflector disks of ceiling inlets reflect the light from outside back up towards the ceiling or walls. The reflected light does not prevent the birds from getting their rest.

By properly configuring the climate system and equipping each project with the products and accessories suitable for that specific location, we can make sure that the farmer does not end up with exhausted animals that do not thrive or perform well.

Inlets and extraction openings are handled by actuators managed by a controller. A back up system makes sure that animals are not suffocated should there be a power loss at the farm. The inlets and fan dampers will automatically be set wide open ensuring sufficient natural ventilation airflow in case of emergency such as power loss.

Set at the heart of each climate control system from Munters, you will find a number of controllers which orchestrate the equipment – the silo controller which controls the feed and the Farm Master and Center controllers enabling the farmer to set temperature curves for the building(s), control the minimum ventilation and to track historical data from his/her house. ■

Egg Focus

10. Careful collection

by the technical team, Vencomatic Group, Holland (vencomaticgroup.com)

Maximising the number of first quality eggs that can be sold to the retailer is the key priority for table egg producers worldwide. This means that eggs must be produced by the hens in the best condition possible, but they must also be collected and packed maintaining the highest egg quality.

Speedpack – table egg packer.

An important feature of consumption eggs, and a significant reason for rejecting eggs, is the quality of the eggshell.

Even eggs with minor hairline cracks, a broken shell but with the membranes still intact, cannot be sold. Moreover, hairline cracks increase the risk of bacterial contamination of other eggs, thereby negatively influencing food safety.

Within the logistic chain, 2-7% of the eggshells are damaged. Calculating with an average of 4% damaged eggs, financial losses for a farm with 100,000 layers may mount up to € 16,400 per flock.

Laying hen breeding companies nowadays aim for improving laying duration thereby increasing the production cycles, and the maximum age of laying hens in the industry.

Since eggshell quality deteriorates with age, this goal may conflict with the current quality standards regarding eggshell fractures.

This raises the question of which factors relate to hairline cracks in eggs of older laying hens?

And, more importantly, how do we minimise eggshell damage resulting from collection, packing, and transportation?

The egg way

The way an egg travels from the laying hen to its final destination (the processing industry or perhaps the plate of the consumer) usually consists of many transitions, conveyor belts, transportations by truck or otherwise, and they are not always smooth. The journey starts the moment an egg is laid and falls onto the nest mat.

The height of the drop and softness of the mat influence the landing of the egg. Then, a high angle of the nest mat (over 8°) may result in an extreme speed of the egg when it rolls onto the egg belt behind the nest. Also, transitions from one egg belt to the other may differ too much in height.

Egg traffic from several belts which are connected to each other that eventually end in the egg collection room, may not be correctly controlled.

Overcrowding on the egg belt and low egg density may also increase the risk of egg damage. Next, the egg packing machine should handle eggs gently, and the number of transitions within the egg packer should be minimised.

Evaluating the egg way

Using an electronic egg we are able to evaluate 'The egg way'. This electronic egg measures the level of impact, in terms of acceleration, it encounters during collisions with other eggs or materials. We found that the maximum acceleration of an egg running through the logistic chain is typically 15-45G.

In order to clearly assess the risks of damage to eggs in the transport chain we set up several experiments. In our studies, consumption eggs of relatively old (88 week) hens were exposed to varying collision severity, and fracture occurrence was measured.

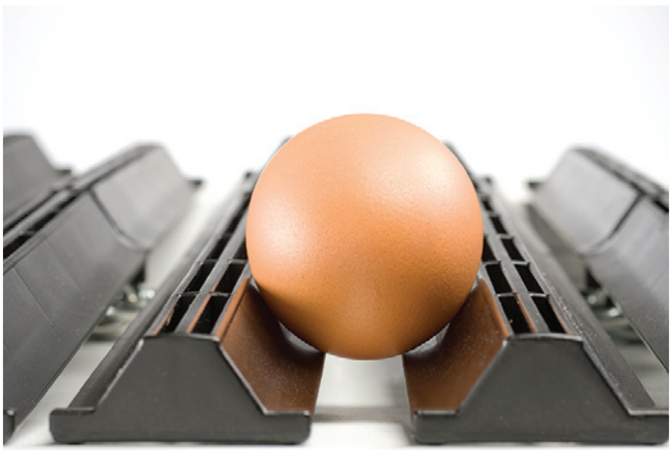
The collisions in our experiments mimicked the impacts an egg typically encounters during collection, packing, and transportation.

Of all experimental eggs, the mechanical properties were measured, including dynamic stiffness, egg weight, shape index, and damping ratio.

The impact energy on the real egg was related to realistic accelerations measured inside the transport chain. To find the tolerances of eggs before damaging, eggs were individually impacted while the impact energy varied, and eggshell quality was assessed afterwards.

With this experimental setup it was possible to relate the chance for eggshell damage to the accelerations that were measured from collisions inside the transport chain.

The Vencobelt egg carrier.



Reducing damage

We found that the chance for eggshell damage correlates negatively with dynamic stiffness, egg weight, shape index, and damping ratio.

The correlations were not very strong: it seemed that an improvement of 50% uniformity in egg weight and dynamic stiffness would result in a moderate decrease in the chance of eggshell damage (by a factor 2).

It is probably possible to reduce the chance of eggshell damage if one would be able to strongly decrease the variation in egg weight and dynamic stiffness.

However, from our studies it appears that a decrease of 30% in impact energy will decrease the risk of crack occurrence drastically (by a factor 10), and likewise, an increase of 30% will increase the chance of crack occurrence by a factor 10.

We found a relatively high sensitivity of fracture occurrence of consumption eggs of older hens towards realistic collisions in the logistic chain.

With respect to hairline cracks, a reduction of collision severity is therefore of first priority when increasing the age of laying hens.

Summary

Increasing the age of laying hens in the consumption egg industry may result in a higher risk for eggshell damage as eggshell quality decreases with hen age.

Therefore financial losses may rise, resulting from rejections of eggs that are not suitable for consumption as table eggs.

Our investigations show that starting from a relatively large crack occurrence percentage, a substantial change in egg mechanical properties will cause only a moderate reduction in the chance of eggshell damage (a factor 2).

On the contrary, a moderate reduction in maximum impact energy will drastically reduce the fracture probability of an egg (a factor 10). This suggests that in order to reduce egg fracture occurrence in eggs, avoiding high impact collisions is a first priority. ■

Egg Focus

11. Building a good shell

by Manu De Laet, Nuscience Group, Belgium (nusciencegroup.com)

Many egg producers currently produce around 360 eggs per hen housed. Genetic companies are currently breeding for more and more eggs per hen. The production cycles will be extremely prolonged and this means that the critical period for second grade eggs and broken eggs will be much longer.

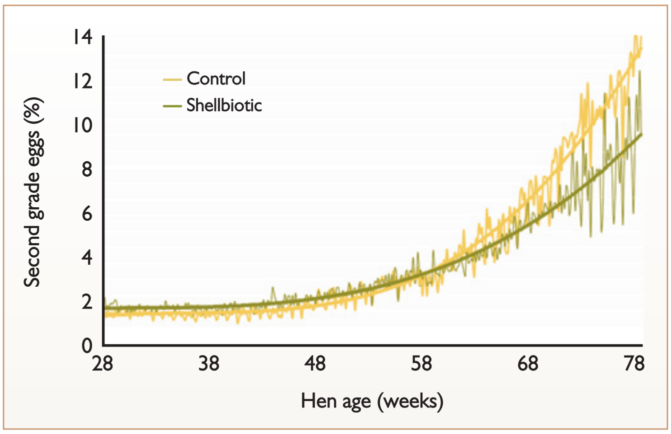


Fig. 3. Increase in second grade eggs can be limited by using MCFAs (yellow line = diet + MCFAs).

Building the shell

Building a good shell is like building a good house with solid foundations. These foundations correspond with the albumen and the surrounding membranes.

The better the albumen and membrane quality, the better the calcification process. It is the time available during the calcification process which determines the thickness of the palisade layer and therefor the major part of the thickness of the shell. However, like while constructing a house, it would not be solid if no defined structure and no cement were used. The same is true for the eggshell. The organic matrix links all the crystals to each other making it a solid structure.

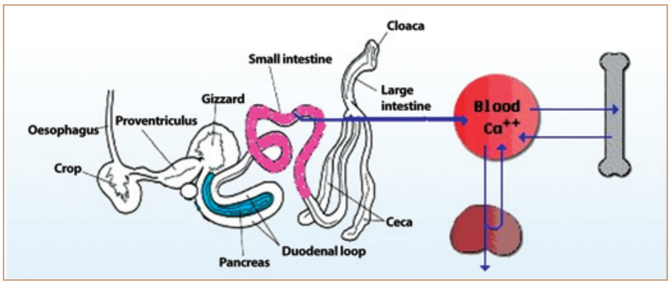


Fig. 1. Fluxes of calcium (Nipane et al., 2011).

Albumen quality is mainly defined and expressed in Haugh Units. This parameter is based on the height of the thick albumen surrounding the yolk in relation to the egg weight. The higher this value, the better the quality.

This albumen quality is a good indicator for the freshness of an egg and for the health of a flock. Albumen quality commonly declines with the age of the bird. High quality albumen results in a direct improvement of the calcification process. This results in less broken eggs.

Egg shell quality decreases with age

Many factors have been found to affect eggshell quality, such as disease, nutritional status of the flock, heat stress and age.

The decline in eggshell quality when the laying hens are getting older may in part be attributed to reduced intestinal calcium uptake as well as to increased egg size.

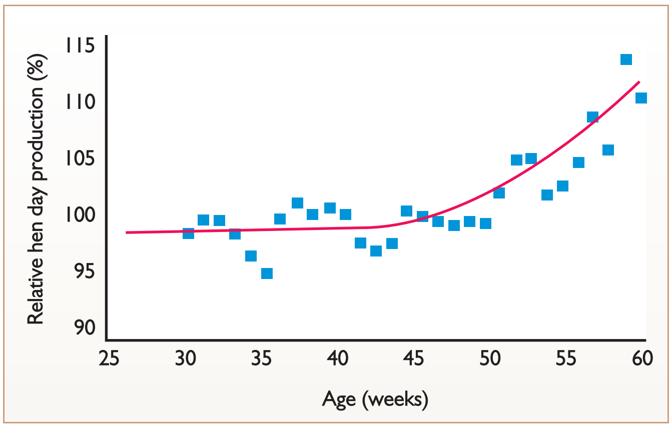
The shell of a hen's egg consists of up to 90-95% calcium carbonate which is embedded in a protein matrix that determines the strength of the egg.

Today's commercial laying hens lay an egg almost daily and therefore require about 4-5g of calcium per day. The eggshell is made essentially from lime, which is made available either from the daily feed supplied or from the bones, especially the medullary bone marrow.

The rate at which calcium is removed from the blood during eggshell formation is greater than the mean rate of calcium absorption from the feed, and the balance is corrected by mobilisation of skeletal reserves (Fig. 1).

The phosphorus liberated simultaneously is largely excreted in the urine. If there is an imbalance in the intestine due to diseases or bad nutrition, the rate of calcium absorption will decline, and the calcium supply to the oviduct will be decreased. In that case, a lot of second grade eggs can be expected.

Fig. 2. Laying percentage MCFA group relative to the laying percentage of the control group (100 = production is equal in both groups).



MCFAs for laying hens

Throughout the years, Nuscience has acquired extensive experience with Medium Chain Fatty Acids (MCFAs). With the knowledge of the different effects of MCFAs and their combinations with Short Chain Fatty Acids (SCFAs) on metabolism and intestinal health, Nuscience was able to increase layer performance.

MCFAs have two types of effects. The long term effect is maintaining better laying persistency.

Due to the time necessary for follicles to develop from small into mature ones, the first 4-6 weeks after start of using MCFAs, no effect on hen day production will be noticeable.

However, once the effect has started, the longer the production period, the bigger the benefit will be (Fig. 2).

In the short term the albumen quality and eggshell quality improved, resulting in less second grade eggs (Fig. 3).

Summary

With the genetic evolution from the last decades, production cycles of laying hens have been and are still prolonging. This implies that the risk of ending up with an increasing number of second grade eggs will be bigger.

These second grade eggs have a severe negative impact on the profitability of the layer industry and should always be minimised.

Therefore, Medium Chain Fatty Acids (MCFAs) are strongly advised to be used. It is best to start when maximum egg mass production is achieved. This is 4-6 weeks before problems with egg quality might be expected. ■

References are available from the author on request

Egg Focus

12. Feeding for health

by Fernando Cisneros, Global Carotenoid Manager, DSM Animal Nutrition and Health

Laying hens are sometimes affected by health issues due to parasites (coccidiosis), worms or viruses, thus hampering the absorption and deposition of carotenoids and leading to pale egg yolks. A bright yolk colour can therefore be considered as an indicator of the good health and performance of the flock.

Historically, carotenoids have been known for their egg yolk pigmenting properties and have been thought to play specific roles in avian embryonic development and hatchability.

Nowadays, a growing body of research shows that when specific carotenoids, such as canthaxanthin, are added to the diet, they can improve the antioxidant properties of the eggs.

Carotenoid absorption

Carotenoid absorption from the intestinal tract can be compared to the intraluminal, membrane and intracellular events of dietary lipids.

Although our understanding of carotenoid absorption in avian species needs further research, findings suggest that in poultry most of the carotenoids are absorbed in the jejunum.

After the ingestion of feed, carotenoids are released from the matrix by digestive enzymes, including lipase, and further emulsified by bile salts and phospholipids.

During the hydrolysis of triglycerides, the monoglycerides formed in the presence of bile salts spontaneously create very small particles called mixed micelles.

The solubilising of water-insoluble materials, including carotenoids, is a critical step in their digestion and absorption.

Particularly small, mixed micelles are dispersed in the aqueous environment of the intestinal lumen and can diffuse into the glycol-protein layer surrounding the microvilli or brush border of mucosal cells, where they come into contact with the cell membranes.

In general, the unstirred water layer can limit lipid absorption and it seems reasonable to assume that the same is true for carotenoids.

It is becoming increasingly evident that micelles formed from dietary lipids serve as a delivery system for carotenoids to reach the absorptive surface of the gut.

The micelles facilitate fat absorption by providing a high concentration of lipids in the unstirred water layer adjacent to the mucosal cells and disruption of the micelles is necessary for absorption to take place.

The feed matrix is thought to be an important determinant for the absorption of carotenoids, as bile secretion depends on the amount and type of feed, while bile salts and fat determine micelle formation.

The pH in the intestinal lumen may also have an effect on absorption, impacting the surface charges of both the micellar particles and the luminal cell membrane, with less diffusion resistance at lower pH.

It thus appears that carotenoids are absorbed by passive diffusion across the brush border membranes of the intestinal mucosal epithelium with a concentration dependent process.

The efficiency of the dispersion of carotenoids is also known to be affected by the presence or absence of other components in the diet, as well as by the general nutritional status of the animal. The presence of fatty acids of varying chain lengths and the degree of saturation, for example, substantially affect carotenoids' absorption rate.

It is generally accepted that plasma lipoproteins serve as a transport system not only for lipids but also for carotenoids.

In birds, portomicrons, lipoproteins produced by enterocytes, serve to transport lipids from the gastrointestinal tract to the liver via portal circulation.

Very Low Density Lipoprotein (VLDL), Low Density Lipoprotein (LDL) and High Density Lipoprotein (HDL) are the major lipoprotein classes of avian plasma.

It is important to understand the interactions between lipoproteins and carotenoids to further understand the physiological status of birds.

Yolk colour reflects the layer's health

Carotenoid absorption and assimilation involve many factors. In particular, any stress or disease-related disturbances at gut level would decrease carotenoid deposition into the egg yolk and therefore decrease its colour intensity.

In poultry, most carotenoids delivered to the egg yolk are feed-derived. Egg formation is a complex process, involving a substantial increase in lipid and protein metabolism in the liver and other organs.

Furthermore, carotenoids are important to the health maintenance of laying hens, and play a key role in their immunocompetence.

There seems to be a trade-off between carotenoids transferred to the egg and those used up by the hen.

The start of the laying period is critical because hens must increase their feed intake quickly to cover the production of the first eggs.

This process undergoes hormonal changes and any deficit can impair further egg production during the cycle. Therefore, the carotenoid content and the yolk intensity can be used as good markers for the flock's status.

Consumers in many countries see eggs with golden yolks as more appetising and nutritious, and there is an opportunity for farmers to offer vividly coloured eggs in the marketplace.

Similar to the effect of gut infections, any stress or disease-related disturbances in the liver or ovaries would decrease carotenoid concentration in the egg yolk. The only way to deliver a brightly coloured egg yolk is to ensure maximum carotenoid absorption in healthy birds that receive enough feed carotenoids.

This is achieved through the reduced use of carotenoids for antioxidant functions in order to get maximum deposition into the yolk. Eggs with a golden yolk are the result of a high degree of husbandry and flock health.

Recommendations

Improvement in genetic potential, as well as the increase in the length of their cycle of production, may impact the rearing of laying hens.

Therefore, new nutritional and health solutions must be found to address new challenges.

As the carotenoid content in the egg can be correlated with the health and performance of a flock, carotenoids, such as the nature-identical canthaxanthin from DSM's Carophyll red, can be added to feed to ensure a golden yolk, every time (in healthy flocks). ■

References are available from the author on request

Egg Focus

13. Improving shell quality

by Jesus Arango, PhD, Statistical Geneticist for Hy-Line International

The practice of extended single-cycle production systems, even those extended up to 100 weeks without a moult, is attainable today because of improved persistency of egg production and better environmental conditions. Additionally, innovative selection programs have helped make this possible without affecting the performance of flocks managed in moulting programs.

One of the most important consequences of this production system is the need for hens that maintain high quality of eggs for a longer time as they age. The persistency of shell quality during long periods of egg production is paramount. Shell quality has been described as the 'limiting factor' in the evolution of single-cycle production because shell quality deteriorates as the hen ages.

Saleable eggs require shells of good quality. The eggshell not only provides a natural package for the egg content, but also provides essential protection from microbial penetration.

Several factors contribute to eggshell deterioration as hens age. The most important are related to calcium nutrition and metabolism: deterioration of the gut's absorption capacity, inefficient mobilisation of body reserves (from medullary bones) and of deposition of ionic form to organic form of this mineral to build the shell wall.

In addition, egg size tends to increase with age enlarging the area to be covered by a limited supply of calcium carbonate. This calls for a holistic approach to improve shell quality in modern layers.

Shell quality is a complex trait dependent on shell resistance to breakage, plasticity and permeability over its entire area. Hy-Line International have been exploring different candidate measurements to be targeted for the improvement of shell resistance.

This has required developing extensive research (both internal and publicly available in scientific literature), which has been summarised in developing a Shell Quality Bio-complex (SQC) for the improvement of shell quality.

The idea is to combine diverse measurements at different hen ages to approach shell quality in a holistic manner. The components of the SQC include multiple (at up to four ages) and repeated records (2-3 eggs) of different measurements (Fig. 1), which have included:

- **Puncture Score (PS):** a non-destructive, semi-static method that tests shell's deformation and plasticity. It measures displacement of the shell upon applying pressure that simulates point of impact, without cracking the shell. It had been the single most important shell resistance trait in the breeding program for over 45 years, which was recently discontinued due to the erosion of available genetic variability.

Fig. 1. Components of the new shell quality evaluation, from left to right: breaking strength at the equator (BSe) and between the poles (BSp), and the Acoustic Egg Test (AET).

- **Breaking Strength (BS):** a static and destructive method to test the blunt force required to break the egg, which is highly correlated with shell thickness. Two directions of this measurement have been tested and implemented: equatorial (BSe) and polar (BSp).

- **Acoustic Egg Test (AET):** the most recently introduced method in the Hy-Line breeding program. It is a dynamic method (as it covers the entire eggshell area). It utilises the egg as a resonance chamber and integrates the resonance profile measured in four quadrants (at 90 degree rotation) and mass of the egg with its shell resistance, providing two main outputs: Dynamic Stiffness (KDyn) and Micro-crack (MCr) detection. The KDyn is a quantitative indicator of integral shell resistance and a good predictor of occurrence of cracks; therefore a good candidate for improvement of shell quality. In an intact egg, frequency spectra profiles at different quadrants are very similar, and tend to be dominated by a single peak (Fig. 2). On the contrary, eggs carrying MCr are characterised by multiple peak profiles, broader frequency and heterogeneous pattern spectra (Fig. 3). A multiple correlation threshold allows defining an intact vs. a cracked egg. A sound layer breeding program, among many other measurements of efficient egg production, must include different measurements of shell quality taken at different ages or stages of the production cycle, such as the ones in the SQC described previously.

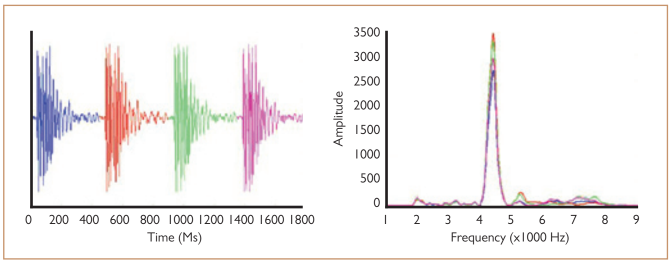


Fig. 2. Acoustic Egg Test (AET), showing the typical frequency spectra of an intact egg. Frequency spectra graph images from: http://www.columbus-tester.com/about-columbus

Results from analyses of these traits indicate that:

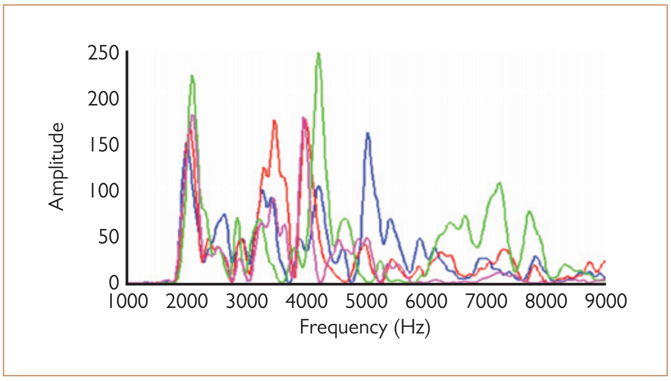
- Direction of measurement of BS is important, and should be considered for selection as genetic correlations between BSe and BSp are much less than 1.0.
- Genetic correlations between BS and Kdyn are positive but moderate, indicating that they measure different aspects of shell quality.
- Crack detection has poor response to selection; but its genetic correlation with BS and Kdyn are favourably negative, and of sizable magnitude, particularly with KDyn. Therefore, the incidence of micro-cracks can be efficiently reduced indirectly by increasing BS and KDyn.

The ability to detect cracks is important, as egg breakage is one of the most important causes of downgrading eggs during classification.

Downgraded eggs are one of the main sources of economic inefficiency of egg production. An approach for a holistic improvement of shell quality (SQC) must aim for ensuring a good shell structure and reduced risk for breakage in both moulting programs and extended cycles of egg production. ■

Ref: Arango et al. (2016). Poultry Science doi: 10.3382/ps/pew286

Fig. 3. Acoustic Egg Test (AET), showing the typical frequency spectra of a cracked egg.



Egg Focus

14. Egg yolk pigmentation

by Fernando Cisneros, Global Category Manager, Carotenoids at DSM.

A golden yolk can only come from a healthy hen and in order for a yolk to present an attractive golden colour, the carotenoids have to:
• Be ingested in sufficient quantities.
• Be absorbed (via a healthy gut).
• Not be used as antioxidants (low immunological challenges).
• Not be used as vitamin precursor (good vitamin status).

Therefore the hen, the environment and the feed have to work together to deliver an attractively pigmented yolk.

In nature, the male birds with the best colouration will attract the females. This makes sense, because only the healthier individuals will be able to obtain appealing feathers. The same goes for the females: the healthier hens will have more carotenoids for their eggs.

So, in order to have a golden yolk, you need a good quality feed, the correct husbandry practices and – more importantly – a healthy hen.

Pigmentation efficiency

The egg yolk pigmenting efficiency of carotenoids is determined by two main factors – egg yolk deposition rate and carotenoid colour (wavelength).

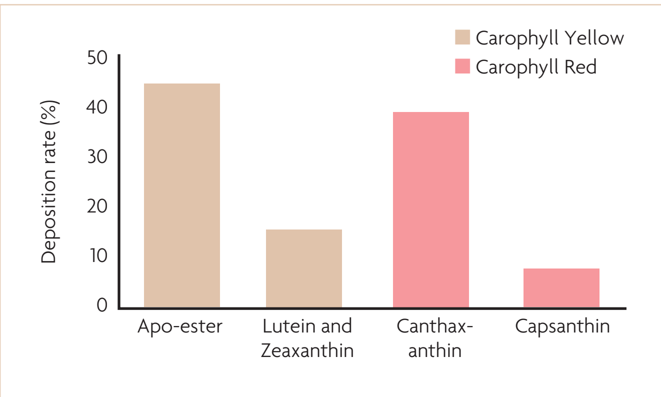
Deposition in egg yolk

Deposition of dietary carotenoids in the egg yolk depends on the individual carotenoid molecule (Fig. 1). As the content of carotenoids in the feed increases, their concentration in the egg yolk rises in direct proportion.

The colour of carotenoids

The wavelengths of the colours of the carotenoids used for egg yolk pigmentation fall between 400nm and 600nm within the visible range of the colour spectrum (Fig. 2).

Fig. 1. Egg yolk deposition rates of various carotenoids.



To the human eye, such compounds are yellow to red in colour.

Lutein, zeaxanthin and apo-ester are yellow carotenoids (wavelength from 445-450nm), whereas canthaxanthin is a red carotenoid (wavelength from 465-470nm).

Egg yolk pigmentation

There are two components of egg yolk pigmentation.

The first (referred to as the saturation phase) involves the deposition of yellow carotenoids to create a yellow base corresponding to a DSM YolkFan score around 7.

Such a yellow base is very important for good saturation of the final colour.

Once the yellow base is established, the addition of the red carotenoid canthaxanthin (Carophyll red) changes the hue to a more orange-red colour (the second component, or colour phase).

The 16 blade DSM YolkFan.

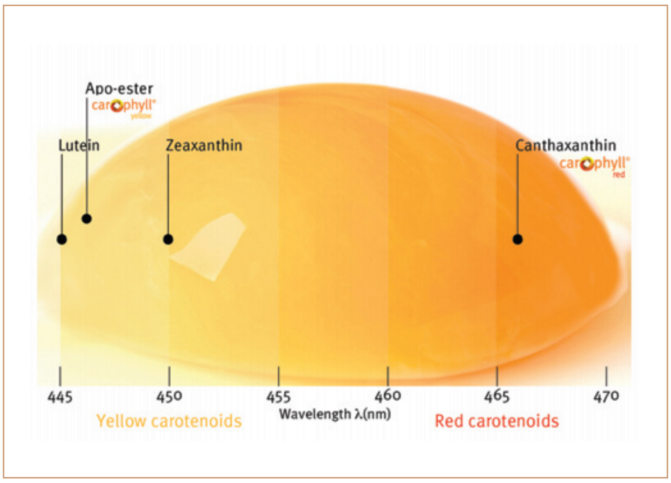


Fig. 2. Wavelengths of various carotenoids used for yolk pigmentation.

The dose-related colour response to red carotenoids is higher than the response to yellow carotenoids, and the combination of yellow and red carotenoids is therefore more cost-effective for egg yolk pigmentation.

Regarding the relative pigmenting efficiencies of the yellow carotenoids, apo-ester (Carophyll yellow) is more efficient than lutein and zeaxanthin, the main carotenoids in feedstuffs.

The very high deposition rate of apo-ester (Carophyll yellow) makes it the most suitable yellow carotenoid for the saturation phase.

YolkFan development

During the last few years, the global egg industry (especially in Asia) has been experiencing an accelerated development, leading to a proliferation of brands and market offers.

The idea of a golden yolk always coming from a healthy hen is being adopted widely and, as a consequence, we have consumers asking for a deeper shade of colour in their eggs.

For this very reason, DSM customers asked us a few years back for the new and higher blade numbers for the DSM YolkFan.

Our scientists in France and Switzerland set about constructing the requisite blade and developing the accompanying recommendations, with the support of our marketing team in Asia-Pacific.

Trials were carried out, yolks were evaluated via chemical and optical analysis, and the appropriate samples were sent to the ink developing supplier.

Taking yolk colour assessment a step forward, DSM is now launching the Digital YolkFan in order to take yolk colour evaluation into the digital era. A digital extension of the DSM YolkFan, the Digital YolkFan provides fast, accurate colour evaluation and can be used in conjunction with the 2016 egg yolk pigmentation guidelines for optimal, consistent yolk colour production.

Consistent colour

Carophyll yellow 10% and Carophyll red 10% are free-flowing, granulated carotenoid products.

They consist of small beadlets in which the carotenoid is finely distributed in a starch-encapsulated plant and carbohydrate matrix to which antioxidants have been added, making Carophyll products animal-free.

The special manufacturing process, known as 'spray-dried coating', protects the carotenoids against oxidation and gives them high stability, water dispersability, outstanding mixing properties, and very good absorption characteristics. ■

Please see page 39 for more information on the digital YolkFan available from DSM.