Egg quality manual

A practical guide to the efficient evaluation of egg quality at farm level

dsm-firmenich

Introduction

The formation of the egg is a natural but complex process. It requires the right nutrients at the appropriate levels and time, a sound reproductive system, a healthy hen and the right environment.

While each main component of the egg (shell, albumen and yolk) has a well-defined structure, eggs will show many variations in shape, size, color of the shell and color of the yolk. These differences can be due to the breed of hens, the type of nutrition provided, the age of the flock or simply to individual variations. In addition, once laid, the egg quality will be modified over time due to the exchange of gases with the environment and losses of moisture.

The quality of eggs is paramount to egg producers as they strive to meet the expectations of customers, realize their internal financial objectives and ensure the sustainability of egg production. Poor egg shell quality or inconsistent yolk color will have serious financial consequences.

This dsm-firmenich's Egg Quality Manual offers a quick reference guide to producers on some of the main causes for egg quality issues and how they can be detected and monitored before they constitute a financial burden to their farms.

Egg evaluation

The on-farm evaluation of egg quality has two main purposes:

1. To review the status of a given farm or flock/barn. This is usually carried out in a central location and it will require at least 30 eggs per barn and test.
1. To benchmark the quality of eggs against the offering of competitors. This evaluation will include all the quality parameters expressed in this booklet. It also includes all the marketing data such as pack size, packing material, price and claims. Benchmarking is usually performed in urban centers and supermarkets, giving a flash picture of the situation in a very specific location and period of time.

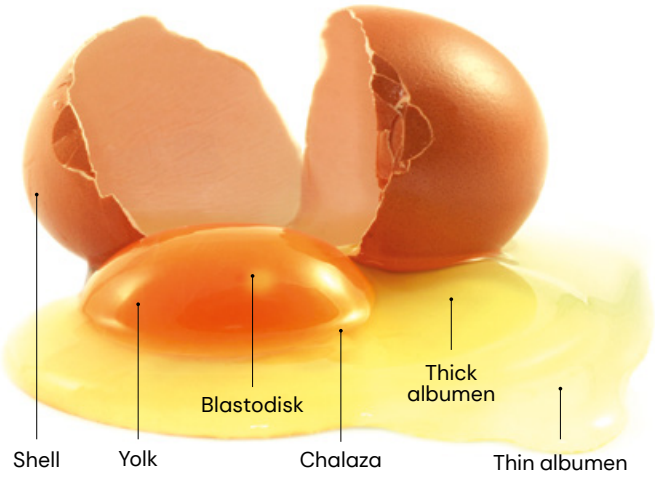
Egg structure

The egg is made of three distinct parts, the shell (10% of weight), the albumen (60% of weight) and the yolk (30% of weight), each contributing to the great success of eggs as a complete nutritious food.

The shell provides both physical and biological protection from the environment and regulates the exchanges of water and gases. The shell inner and outer membranes constitute the base upon which the precipitation of calcium carbonate on the organic matrix produce the shell in about 20 hours during the passage in the uterus.

The cuticle, containing a large portion of the superficial pigments, is laid on the external surface of the egg. At the large end of the egg, the air cell is formed after laying when gases penetrate through the numerous pores in the shell. Its size increases with time as eggs lose moisture.

The yolk, surrounded by the vitelline membrane, contains about 50% water, 30% lipids and 17% proteins. In addition, the yolk is rich in fat soluble vitamins (A, D, and E), minerals (Phosphorus), and carotenoids, which give the yolk its golden color. The albumen or egg white (thick and thin, chalazae and chalaza layer) consists mostly of water and proteins (10%). The chalazae, attached to the thick albumen, anchors the yolk to the center of the egg.



Egg size

Shape and weight are two important dimensions of eggs.

Eggs have a typical oval shape that may become slightly more elongated over the laying cycle as a result of the weakening of the muscle tone of the uterus.

Stress during the early stages of the shell formation can also affect the shape of eggs and create grooves and ridges. Occasionally, hens can lay abnormally large eggs (very often double-yolk eggs) or very small and rounded eggs (often lacking albumen). Large eggs are laid by older flocks, while small eggs are often seen with younger flocks.

The weight of eggs depends mainly on factors related to the hens (genetics and age) and nutrition during the laying period. Egg weight increases with the age of birds and with higher level of proteins in the ration, with an extra 1g of protein consumed per day translating into an average increase of 1.4g in egg weight.

Sudden drops in feed consumption will lead to lower egg weight. Egg weight is used in many countries to grade and sell the eggs with a premium obtained for a particular targeted weight.

Shell quality: appearance and cleanness

The eggshell will be typically clean and smooth throughout its surface and uniform in color. Its appearance has a strong marketing appeal in many countries.

Eggs can become dirty with feces, blood, egg content or feed. Eggs stained with blood are more often seen in younger hens as a result of a prolapse.

The surface of the shell may present some small protrusions, indentations or areas of granular calcareous deposit. Conversely, the eggs can also present a very soft shell or no shell at all. These defects are often caused by the structural disruption of the shell membranes where mineralization is initiated, by a lack of mineralization due to calcium absorption, mobilization or deposition issues or the time spent in the uterus.

Eggs are typically white, brown or light brown/cream although the shell may also be tinged with other colors like blue or green. The color of the shell is a reflection of the breed, age and the health status of the laying hens. It is not modified by the type of feed given to birds.

Since the same amount of pigments are deposited on the cuticle regardless of the size of the eggs, larger brown eggs will have a slightly lighter tinge than small ones.

Visual inspection and automated equipment easily identifies the eggs with defective appearance and cleanness. Healthy hens, good nutrition and good husbandry practices mitigate many of the causes of dirty eggs.

Shell quality: thickness and strength

The quality of the shell is important to ensure the profitability and sustainability of egg production.

The shell, formed by the precipitation of calcium carbonate onto the eggshell membranes, requires about 2.3g of calcium which the hen must obtain from the diet as well as from the medullary bone. For both the absorption of calcium from the intestine and the mobilization from the bones, the hen requires high levels of 25-OH-vitamin D3 in its blood, the metabolite used for measuring vitamin D nutritional status. Therefore, in addition to the right amount and presentation form of calcium in the diet, hens must also be provided with the appropriate level and form of vitamin D3. The dietary provision of 25(OH) D3 will allow for a higher plasma level of the metabolite and therefore a better Ca absorption.

The shell is about 300-400 micrometers in thickness and can withstand a breaking force of at least 30 Newtons. Shell thickness and strength tend to decrease with the age of the hens if the egg size increases (more cracked eggs) but the right balance of vitamin D3 and calcium (in coarse form) will protect over time the integrity of the shell. Manual candling and automated systems can detect cracks and small shell defects.

Shell strength is related to the amount of force needed for an egg to crack. The higher the value, the more resistant the egg is. It is generally measured as kgf but can sometimes be expressed as Newtons (kgf *9.8). Several automated machines like the Nabel DET 6500 (laboratory multitasker device) or the specialized ORKA egg force reader (portable device) can perform these measurements.

To measure the shell thickness, a suitable micrometer is used (Fig.1). A portion of the shell, taken from the equator of the egg for consistency, is always measured after removing the membrane. The measurement can be taken directly.

Fig.1

Egg freshness: albumen

Thick albumen accounts for about 60% of the albumen in freshly laid eggs. As the albumen contains a large amount of carbon dioxide, its pH ranges from 5.6 to 7.5 with time and gas exchanges with the outside environment. When the carbon dioxide dissipates, the pH of the albumen rises to about 9.5. This rise in pH will affect the structure of ovomucin – a glycoprotein found in larger proportion in the thick albumen – and will make the albumen lose its viscosity. The percentage of thick albumen – a reflection of the quality of the albumen – decreases with storage time, and more rapidly at higher temperatures. A visual inspection of the albumen after breaking can provide a good indication of the freshness of the egg.

While pH can be measured to determine the quality of the albumen, the most commonly used method is the determination of the Haugh unit (HU). An equation combining the weight of the egg with the height of the central portion of the thick albumen determines the HU, which is a reflection of the extent of the deterioration of the thick albumen. Fresh eggs from young flocks will have a HU of 85 and above.

The HU decreases with the age of a flock and the storage conditions (length and temperature). Manual and automated devices allow to easily measure the HU.

To measure HU, the following formula can be used: $HU=100\log(H-1.7W^{0.37+7.6})$ where H is the height of the albumen (mm) and W is the weight of the egg. In a simplified version, the below table can be used to calculate HUs from albumen height and weight (Kashimori, 2021). The height of the albumen should be taken around one cm away from the yolk and a digital device is preferred, and a small scale should be used to measure the weight. The formula can be included in a regular spreadsheet to quickly calculate the HU.

Table 1: Haugh Unit Conversion Table

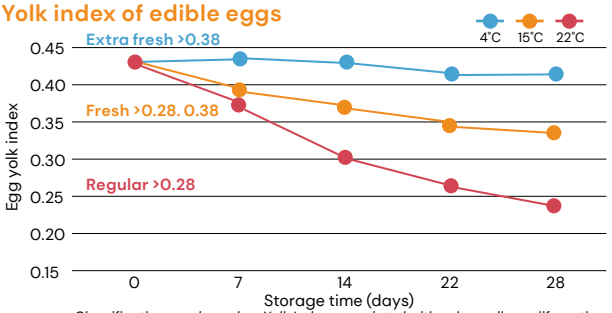
<30 30–60 >60

Egg weight (g)	Albumen height (mm)									
	2	3	4	5	6	7	8	9	10	11
40	47	60	69	77	84	90	95	100	104	108
45	42	51	62	72	79	86	91	96	101	105
50	37	49	61	70	78	85	91	96	100	104
55	32	46	59	69	77	84	90	95	100	104
60	27	44	58	68	76	83	89	94	99	103
65	21	42	56	67	75	82	88	94	98	103
70	15	40	54	65	74	81	88	93	98	102
75	8	37	53	64	73	80	87	92	97	102

Egg freshness: yolk

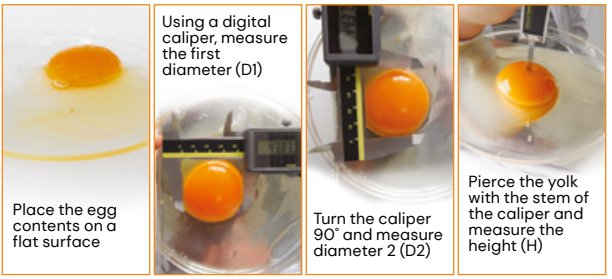
Shape and color are the two main characteristics to evaluate the quality of the yolk. In a fresh egg, the yolk is nearly spherical and stands high with little change in shape once the egg is broken onto a flat surface.

The yolk index, defined as the ratio of yolk height over yolk diameter, provides indication on the freshness of the egg. Eggs with yolk index above 0.38 are considered as extra fresh. Those ranging from 0.28 to 0.38 are fresh and those below 0.28 are considered regular. The yolk index will decrease during storage, although less when eggs are kept under refrigeration as shown below:



Classification was based on Yolk Index associated with salmonella prolifereation

Yolk index is calculated by dividing the height of the yolk by the average diameter of the yolk, as follows:



Calculation: Yolk Index = (Hx2)/D1 + D2

In addition to detecting defects like blood spots at the surface of the yolk, the candling of eggs also provides some information on freshness. During candling, the yolk creates a shadow that is light in fresh eggs as the thick albumen and chalaza keep the yolk in a central position. With time, the albumen becomes thinner and the yolk, moving closer to the shell upon rotating the egg, creates a darker shadow.

Yolk evaluation: color

In addition to water, lipids and proteins, the yolk contains carotenoids which are responsible for the color of the yolk.

As the hens cannot synthesize them, all carotenoids present in the yolk come from the rations fed to laying hens. Rations containing yellow corn, corn gluten meal, lucerne, xanthophyll-rich ingredients like flower (marigold), plant (paprika) extracts or specialty ingredients like CAROPHYLL® will supply more carotenoids than wheat-based rations. Therefore, the color, intensity, shade and homogeneity of the yolk is dependent on the rations fed to hens and their ability to properly absorb and deposit carotenoids in the yolk.

In many countries, consumers prefer a nice, golden yolk and egg producers must ensure that they consistently meet these expectations by monitoring the intensity of the yolk color and adjusting the formulation of the rations fed to laying hens accordingly.

dsm-firmenich's YolkFan™, with yolk color blades numbered from 1 to 16, has been used for decades to assist producers in meeting the expectations of their customers. www.dsm.com/markets/anh/en_US/products/products-solutions/products_solutions_tools/Products_solutions_tools_EggYolk.html

The Digital YolkFan™ Pro, is also available to facilitate the evaluation, recording and management of the yolk color within a flock – making data collection and management much easier. https://digitalyolkfan.com

Nutritive value of eggs

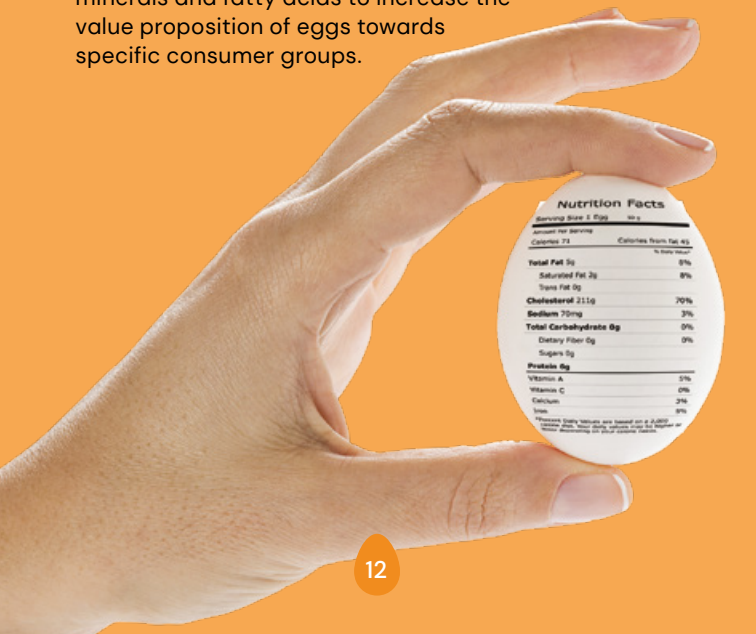
Eggs are one of the most known and accepted foods by consumers around the world.

They are widely recognized as a source of high quality proteins, several fat-soluble vitamins (for example vitamins A, D and E), water-soluble vitamins (for example vitamin B_{12}, riboflavin and folate) as well as a number of micronutrients (for example Iodine, Iron, Phosphorus and Selenium).

The quality of proteins is based on their amino acid composition and digestibility. Eggs provide the best profile for essential amino acids; the protein-building blocks which humans cannot synthesize and must find in their diets.

Combined with a digestibility of 98%, cooked eggs have the highest biological value of any single food protein. Eggs are categorized as a low energy, carbohydrate-free food that contribute to the human diet at all stages of life.

One egg provides 6g of high quality protein and it's a good source of riboflavin, B_{12} and Folate. Moreover, eggs are an ideal vehicle for the delivery of specific nutrients like vitamins, carotenoids, minerals and fatty acids to increase the value proposition of eggs towards specific consumer groups.



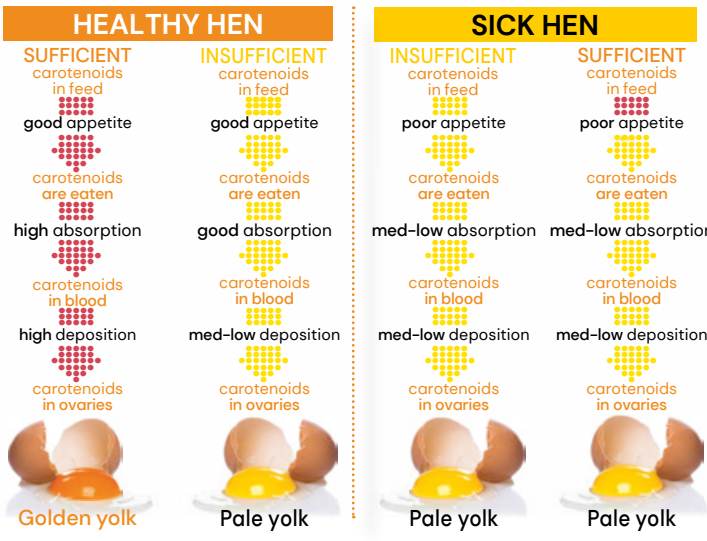
A golden yolk can only come from a healthy hen

In order for a yolk to present an attractive golden color, carotenoids have to:

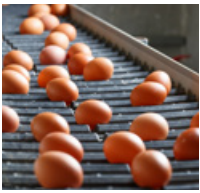
- be ingested in sufficient quantities
- absorbed (via an optimally functioning gut)
- not be used as antioxidants (need low immunological challenges)
- not be used as vitamin precursor (need good vitamin status).

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

In nature, the male birds with the best coloration 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.



Sustainability of the egg industry



The egg industry has the lowest total greenhouse gas emissions (~200 million tons of C02 equivalent in 2013) and the lowest emission intensity (~30kg of C02 equivalent/per kg of proteins produced) of all livestock productions.

The main sources of emissions allocated to egg production are related to feeds (~70%) and manure management (~20%). The composition and quality of rations given to laying hens contribute greatly to the optimum gut function and the efficient absorption of nutrients.

The use of quality feed ingredients and feed technology such as low protein diets, enzymes, vitamins, minerals and ingredients favouring an optimal gut function, allows the egg sector to produce more eggs with the same amount of feed, improving its productivity and profitability while reducing its overall impact on the environment.

The other factors that have contributed to the profitability and sustainability of egg production over the years are: health and wellbeing of hens, low mortality, better bone health and genetic selection.

By adopting the best practices in terms of animal husbandry, nutrition and manure management, the egg industry will be able to further reduce its impact on the environment while increasing its production and profitability.

dsm-firmenich's Evaluation Card

The egg quality score card below is provided as a guideline for monitoring egg quality. Expected values are derived from a database of a flock at peak and optimum production.

	Average	Range (Min-Max)	Minimum acceptable
Egg Weight (g)	60	30-85	Depends on market
Shell breaking strength (kgf)	4.2	1-7.5	3-3.2 depending on strain, hen age and size
Shell thickness (mm)	0.4	0.20-0.57	0.3

	Values	Observation
Yolk color	1-16	In the YolkFan™ scale. Should be uniform (absent of white or dark spots)
Yolk index Regular eggs Fresh eggs Extra fresh eggs	<0.28 0.29 - 0.38 >0.38	Reliable indicator of freshness. It decreases with storage time and temperature
Thick albumen height (mm)	3-10	Decreases with storage-time and temperature
Haugh Unit	35-100	
Meat/Blood spots	Y/N	Absence of Meat/blood spots should be observed
Mottled yolks	Y/N	


Mottled yolk

We bring progress to life

For more information, contact
your representative today.

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