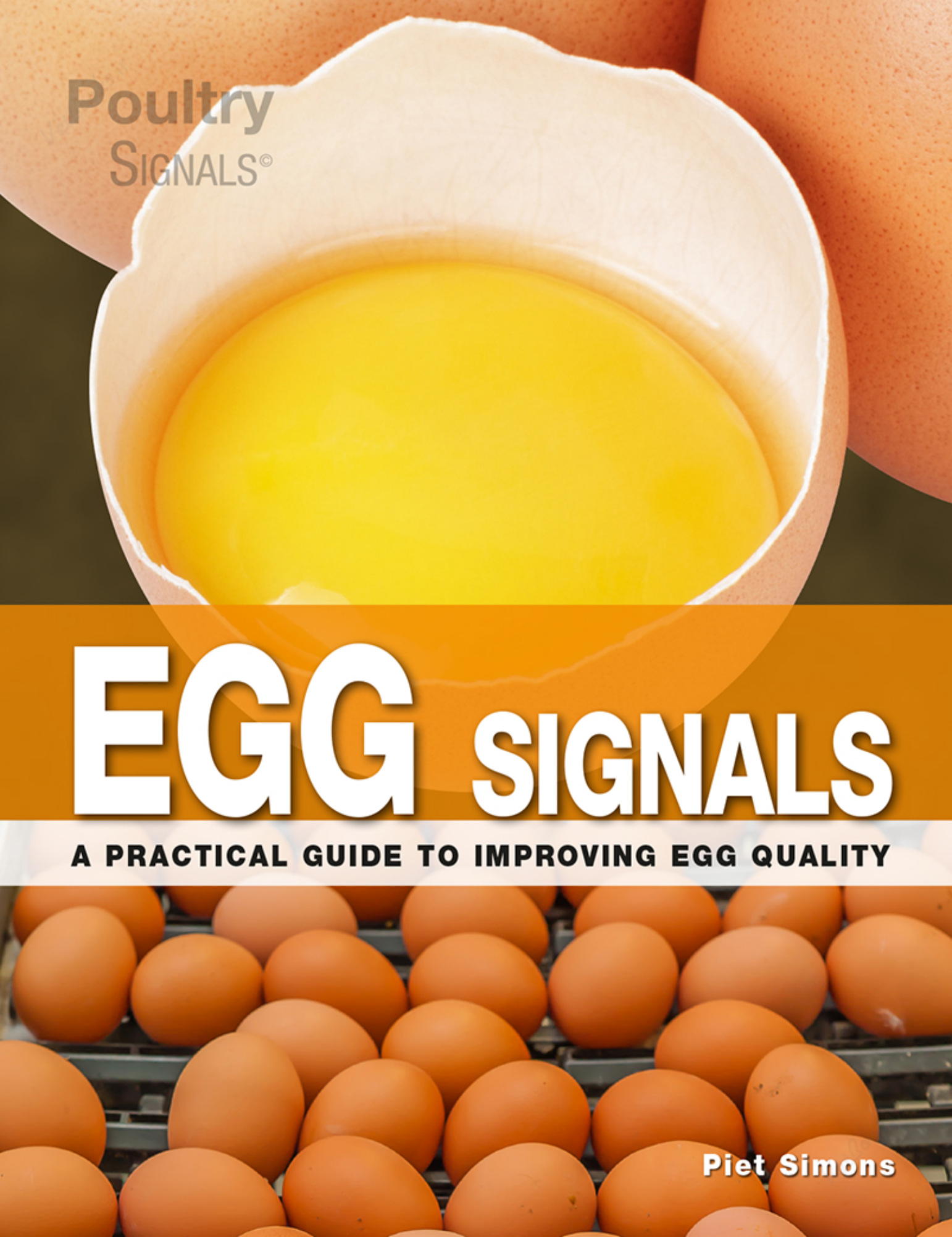

Poultry
SIGNALS©
EGG SIGNALS
A PRACTICAL GUIDE TO IMPROVING EGG QUALITY
Piet Simons

Poultry
SIGNALS©

EGG SIGNALS

A PRACTICAL GUIDE TO IMPROVING EGG QUALITY

Piet Simons

ROODBONT
AGRICULTURAL PUBLISHERS

Credits

Egg Signals

Publisher
Roodbont Publishers B.V.

Authors
Piet Simons
Ton van Schie
Jolanda Holleman (Windkracht 10)

Editorial Staff
Ton van Schie, Christel Lubbers

Translation English edition
First Edition Translations Ltd

Content editors English edition
Maureen Bain
Dustin Banks
Dietmar Flock

Layout
Studio Hiddink

Illustrations
Trudy Michels

Photography
Main photographer: Marcel Berendsen

Additional credits: André Karwath (17), Bloemendaal eierhandel (9), Bulk Agro (16), Clare Sheppard (142) De Heus (72, 121), Diana Marcelino (143), Dreamstime (Belinda Wu (151), Crossstudio (44), Czuber (14), Darryl Brooks (42), Elena Abramova (14), Ioan Florin Cnejevici (56), Konstantin Kirillov (12), Lim Seng Kui (138), Melica (57), Paul Brighton (151), Robyn Mackenzie (51), Rosemary Buffoni (151), Svehlik21 (46), Tanawat Pontchour (151), Tsekhmister (24)), DSM (48, 49), Edward Maylian (93, 93, 93), Eicom (16, 158), Emma Morano (15), Éva Valicsek (143), Frank Wegdam (29), Freiland GmbH (144), GD (39, 40), Gil Rodrigues (143), H. Zell (50), Hippolyte (152), Ivan Dinev (68), Jan Cortenbach (140), Jan Smit (32), Jan van Esch (78, 94, 95, 99, 100, 101, 105, 112, 113, 119, 123, 124, 125, 133, 134), Klaas van Harn (99, 127), Koos Groenewold (105), Koos van Middelkoop (114), Mach-C (136), Marinette Hoogendoorn (28), Mark den Ouden (154), Maureen Bain (77), Moba (98, 126, 128, 135, 137), Monique Bestman (74), NRCS_Photo_Gallery (43), Nuovo printing systems (129, 130, 131, 132, 134), Otília Erdélyi (143), PaperFoam (140), Paul Buisman (136, 137), Piet Simons (2, 65, 66, 67, 73, 76, 78, 81, 82), Porphyrio (7), Randy Ludacer (144), Teun van de Braak (52, 53, 60, 61, 62, 63, 91, 98), Thea van Niekerk (83, 97), Ton van Schie (112, 150), TSS (21, 49, 65, 71, 75, 87, 121), Twinpack (144), Vat 19 (145), WATT Media (5), Wikimedia, ElinorD (44), Wouter Steenhuisen (85), WUR ASG (35), Yeo Guan Soon (146).

With thanks to
Maureen Bain, Willie Blokvoort, Eric Borren, Teun van de Braak, Henno van den Bruinhof, Paul Buisman, Esther van Butselaar, Ben Dellaert, Christoffer Ernst, Jan van Esch, Dietmar Flock, Aart Goede, Naoki Goto, Josje Hakker, Henk van Hamersveld, Klaas van Harn, Theo Hoen, Theo Koekkoek, Shang Lei, Gregorio Lopez, Rob Lunenburg, Edward Maylian, Koos van Middelkoop, Thea van Niekerk, Gerwin Roelofs, José Eduardo dos Santos, Frans van Sambeek, Fam. Thomassen, Kees van der Velden, René Versteeg, Aart-Jan Vos, Bastiaan Vroegindeweij, Frank Wegdam, Frank Westerbeek, Fam. Van Woudenberg.

ROODBONT
AGRICULTURAL PUBLISHERS

Roodbont Publishers B.V.
P.O. Box 4103
7200 BC Zutphen
The Netherlands
T +31 575 54 56 88
E info@roodbont.com
I www.roodbont.com

Egg Signals is part of the *Poultry Signals*© series

ISBN 978-90-8740-272-3

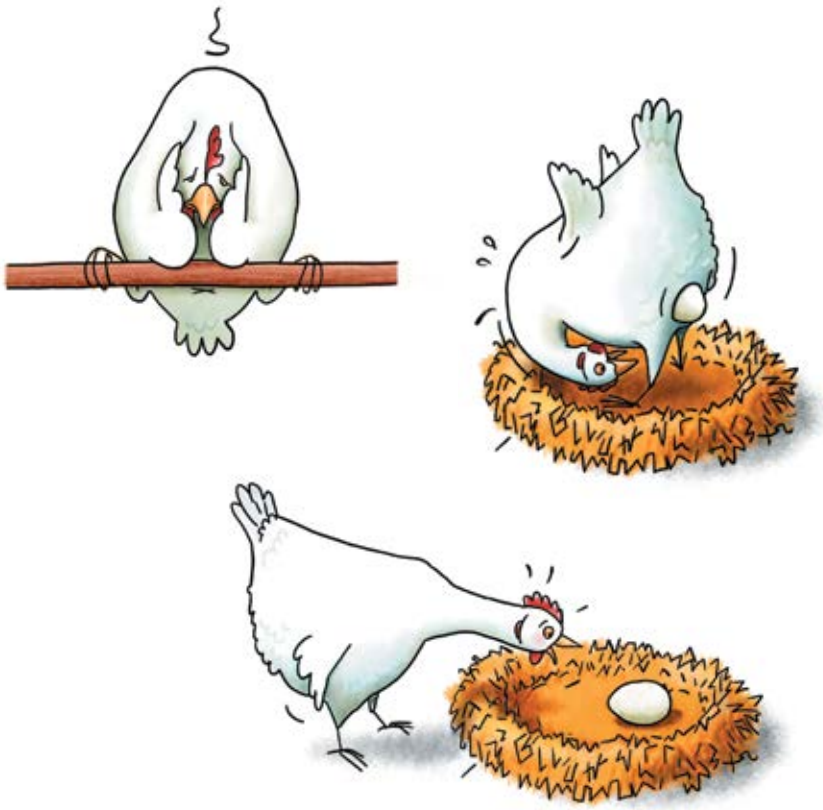
For more information please check
www.eggsignals.com

About the author

Piet Simons, former researcher at the Spelderholt Poultry Research Centre, received his PhD from Wageningen University in 1971, and was secretary/treasurer of the Dutch branch of the World's Poultry Science Association from 1977 to 1991 and president up to 2002. He is an honorary past president of the World's Poultry Science Association worldwide, and was also secretary general for twelve years. In 2006 he received the McDougall Medal for his exemplary services to WPSA. In 2008 he was honoured to be selected for the International Poultry Hall of Fame (IPHF). Piet is currently president of the Foundation for Promoting Poultry Science and the ambassador of Dutch Poultry Centre in the Netherlands.

Contents

Chicken or egg?



Chubby chicken,
Laid no eggs!
Slept all day and night instead!
Slept through sun, slept through rain...
Laying eggs is such a pain...
Don't wanna make, not one egg yolk,
I'd rather sleep or hear a joke,
Don't wanna' make, not one eggshell,
I'd rather sleep, can't you tell?
Chalazae, air-cell, and albumin,
I'll take a pass, I'll be snoozin',
Making eggs, What a pain!
I'll sleep, and sleep, and sleep again!
But chubby chicken, soon 'awoke',
Felt an oval, give a poke,
An egg I made? And I feel fine!
Now I'll lay eggs, all the time!

Chubby Chicken, Mr. R.

There is no egg without a chicken. If you want excellent quality, beautiful, and healthy eggs, you need to ensure that the hen who lays the egg is in top condition, feels good herself, and has all of her needs satisfied. If there is something wrong with the eggs, it is a signal that there is something wrong with the hen or her husbandry. For example, if hens are stressed, eggshell quality will drop.

Egg Signals is a valuable, practical aid for everyone involved in the egg industry. That includes suppliers, consultants, students, and employees in the egg processing sector, poultry farmers, hobby farmers, and other poultry enthusiasts.

Eggs are a very important part of the global food supply. Relative cheapness and abundance make eggs one of the most important animal protein sources for people in poorer countries, along with fish. In wealthier parts of the World, eggs constitute a healthy component of the diet. Worldwide demand for egg production is still growing fast. In the past fifteen years, egg consumption has risen by at least 40%.

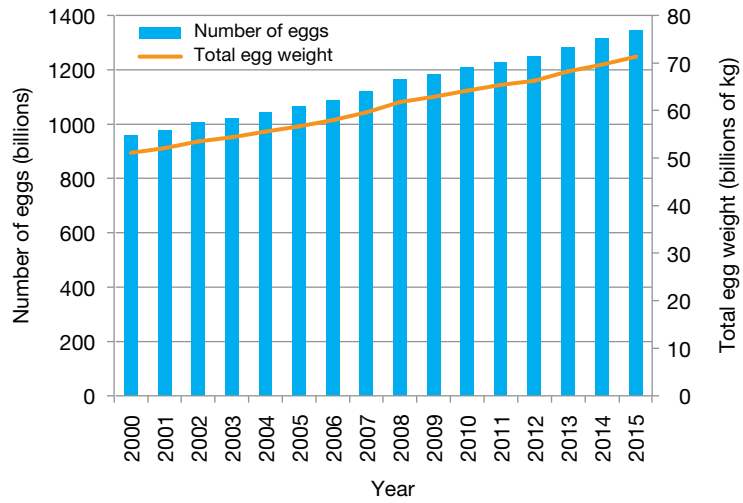
Egg consumption

Egg consumption varies by country. The global average is 165 eggs per person per year. The expectation is that worldwide egg consumption will continue rising until 2025, driven by changing dietary patterns, and rising incomes.

Egg consumption per person for different countries

Country	Number per year
Mexico	350
Japan	300
China	300
Czech Republic	277
Romania	258
USA	250
Germany	233
Thailand	200
The Netherlands	195
Brazil	182
India	47
Average in Africa	35
Rwanda, Burundi	5

Worldwide egg production 2000-2015



Source: www.poultrytrends.com

In 2014, 7.2 billion hens produced 1,320 billion eggs worldwide, with Europe 16%, Asia 59%, North America 9%, South America 7%, and Africa 5%.

Environmental impact

Compared to other sources of animal protein egg production has a relatively low environmental impact. Environmental impact is often expressed in terms of the carbon footprint, or CO_2 emissions per kilogram of product.

CO_2 emissions per kg of product

Product	CO_2	Product	CO_2
Brazilian Beef	30.0	Cheese	8.9
Irish Beef	24.0	Eggs	2.0
Dutch Beef	23.0	Milk	1.2
Beef from dairy cattle	7.0		
Pork	4.5	Cashew nuts	2.3
Poultry meat	2.6	Walnuts	2.1
Farmed salmon	2.1	Beans	1.6

Source: Blonk & LEI

The carbon footprint of beef is about ten times higher than it is for eggs.

CO_2 emissions in different types of egg husbandry system (kg CO_2-equivalent/kg eggs)

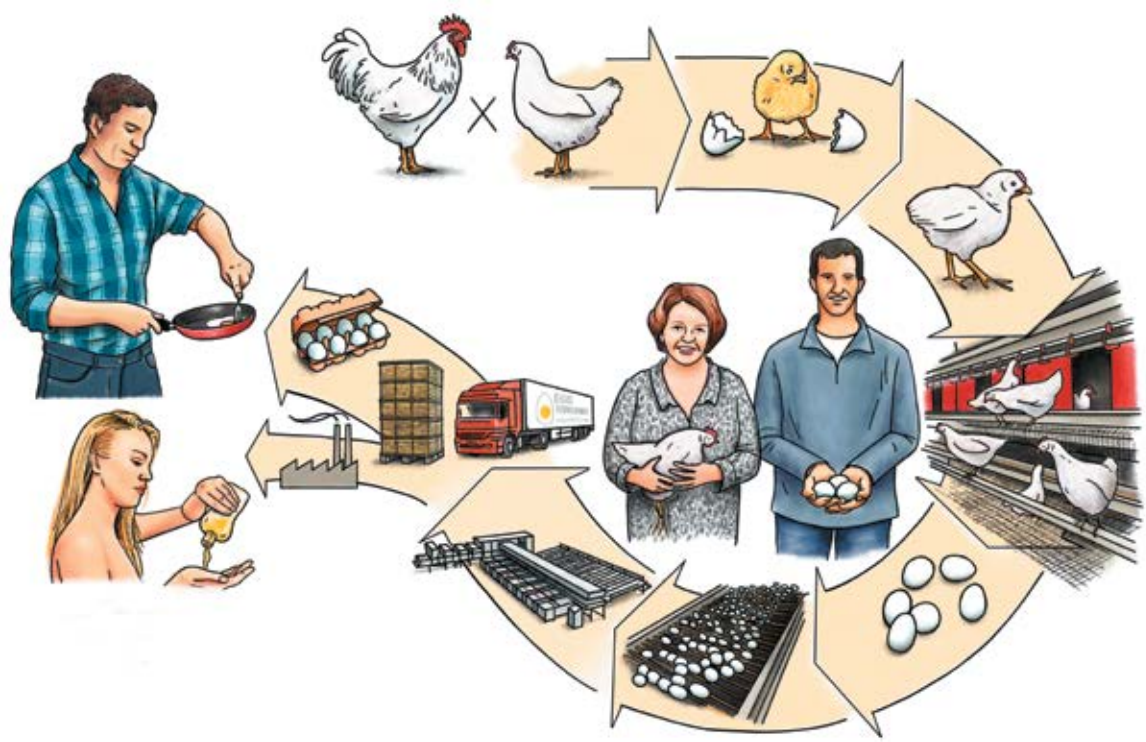
	Colony	Aviary	Free-range	Organic
Feed	1.19	1.33	1.35	1.47
Energy use	0.09	0.1	0.1	0.1
Manure storage/processing	0.18	0.24	0.24	0.44
Manure utilisation	0.09	0.09	0.09	0.18
Processing/retailing	0.2	0.2	0.2	0.2
Total	**1.74**	**1.95**	**1.97**	**2.39**

Source: ABN AMRO and Blonk Milieuadvies

Ensuring egg quality

Egg quality is the general term covering all the characteristics of an egg which influence whether the consumer finds it acceptable or not. The foundation of good egg quality lies in the hen. If the hen is not happy she will not produce a good quality egg.

Egg Signals is not a manual stuffed with standards and criteria, and it does not intend to be the complete solution, but it does provide useful pointers on good hen and egg observation, and how to ensure better results by understanding those signals and acting on them. Being alert every day, being aware of, and interpreting signals from the hen and the egg correctly, will help you to continue producing and processing far into the future. Egg producers in particular must be ready to react and deal with problems quickly to maintain the quality of their product. Egg quality is not completely manageable. If you can take action (like bodycheckers), you will find information in *Egg Signals*. There are also things beyond your control, but it is good to know that. And whether it goes away by itself (double yolks) or that you are stuck with it (IB).



The egg is the end-product of a long production chain, in which each link contributes to delivering the consumer a good egg. In each link however, there are a lot of points where things can go wrong.

Destination

70% of eggs are consumed directly and 30% are processed into egg products. Egg products are used as ingredients for food such as baked goods, pastries, meat, and dairy products, soups, etc.

Signals from numbers

There is a lot of data recorded on egg producing farms. Take the time to analyse it thoroughly. Make sure that your data gives you a reliable picture of how your flock is performing. Keep your records up to date and record information at the same time each day. That way if something changes it will become clear quickly. For example, an abrupt change in water consumption is usually the first signal that something is wrong with the flock health or the feed (e.g. too much salt). Or, of course, it could also be a problem with the drinking water system itself.

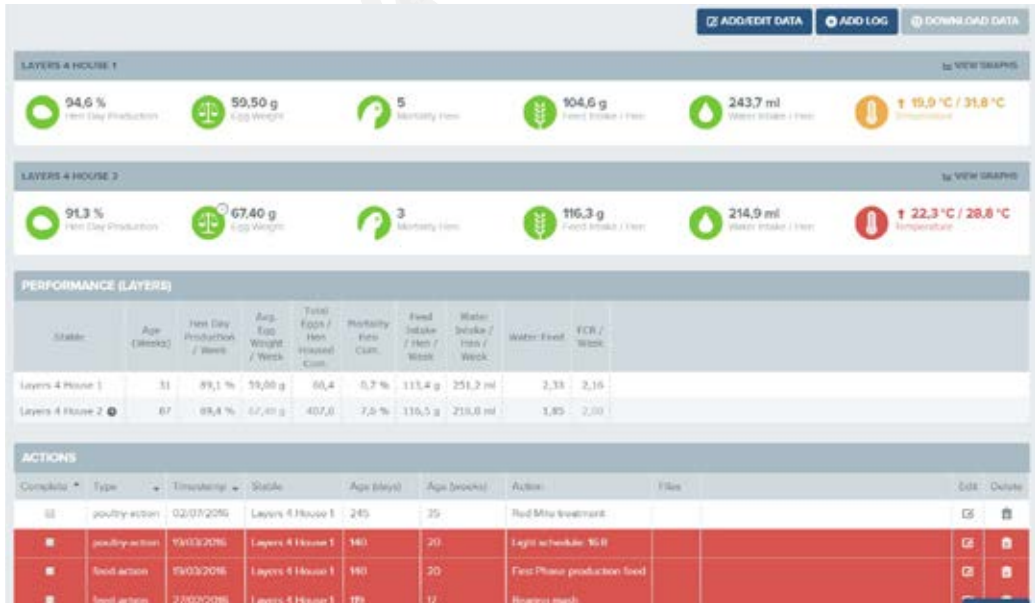
Also take note of signs from the people you supply. Your eggs are graded on a great number of characteristics. The quality report that follows can tell you a great deal about areas in which you can improve, e.g. egg weight, yolk colour, and shell damage. Reviewing this data regularly will help you to anticipate and correct problems proactively instead of taking action when you finally get a warning from your customer.

Prevent professional blindness

You can only see problems and abnormalities if you know what is normal, and the only way to learn what is normal is through experience. But experience can also lead to you finding things normal when they are actually not normal. In other words you have to be careful to avoid professional blindness. You can prevent this by being open minded, and keeping up critical discussions with colleagues, vets, and consultants and applying the tips you pick up from them.

Two people can evaluate the same situation in totally different ways. The poultry farmer sees lots of beautiful chickens, while the vet notices there are a number of sick ones among them.

A house record sheet on paper or nowadays on a computer, tablet, or smartphone provides important management data on a daily basis.



Supplier : 01010 C. Little
Week : 2016-50

QUALITY REPORT

House	Article	Weighing list	Avg weight	Yolk colour	Breaking strength	Haugh Units	Air chamber	Dirty	Leaker	Cracks	gpe	Total %	Q	2 grade separate	Egg print	Flock age
1	ORGANIC EGGS	06043087	59.77	7.0	44	82	2	0.1	0.1	2.7		2.9	2		'good'	27
	UNSORTED	2016-49	59.53	7.0	44	82	2	0.1	0.2	2.2		2.5				27
	0-UK-3265835 OKO	2016-48	58.46	7.0	44	82	2	0.2	0.2	2.8		3.2				27
2	ORGANIC EGGS	06043088	57.19	7.0	39	80	2	0.5	0.6	3.5		5.1	3		'good'	27
	UNSORTED	2016-49	57.27	7.0	42	81	2	0.1	0.2	2.8		3.1				27
	0-nl-326536 OKO	2016-48	57.45	7.0	43	82	2	0.1	0.1	3.3		3.5				27

Reports from the people you supply provide a lot of information. It may be retrospective, but you can still use this data to make management decisions moving forward. In this case, there were problems with shell strength in the last delivery.

See more through better observation

Good care of the hens on your farm and their eggs begins with regular critical and conscientious observations. Take a step back, sometimes, literally. You cannot observe conscientiously if you are preoccupied with other tasks. Take the time to look for and recognise the signal the birds are sending you. Take a good look at the egg size, hairline cracks and other breakages, and the shell quality and colour. The eggs can tell you a lot about your hens and the system. Each signal calls for a different reaction.

LOOK-THINK-ACT

The guiding principle in *Egg Signals* is LOOK-THINK-ACT. The three basic questions that you must ask yourself time and again are:

1. What am I observing? – i.e. seeing, hearing, smelling, and feeling
2. Why is that?
3. What should I do?

In this book, we will often challenge readers to first consider matters by themselves, using the LOOK-THINK-ACT boxes.

Try to answer the question yourself before reading further.

Structured observation

By structured observation, we mean that you really take the time to seek out the signals.

You implement structured observation like this:

1. Observe when you are not doing any other task.
2. Stand still in the house at regular times, possibly during egg collection, and do not just keep on working or moving constantly.
3. Observe both the eggs and hens. First look at the flock generally, then concentrate on the individuals, and then go back to general observation once more.
4. Look at the averages and the extremes.
5. Make your observations at the beginning, end, and in the middle of the house or egg belt.
6. Observe at different times and under varying conditions.
7. Identify risky times, locations, and any birds which are not performing optimally.

Noticing signals at a very early stage requires professional skills.

LOOK-THINK-ACT

What caused this pinhole?

Look: There is a small hole in the shell.

Think: A pinhole starts with tiny damage to the egg shell.

Act: Check the inclination of the nest box and protruding parts in the next box (possible pressure on egg points when falling).

Taking the signals on board

You can learn a lot from a flock and the eggs during your daily tasks. But you should also carry out a specific inspection when you have no other tasks to do. You can pick up signals more easily and be more aware of them when you can give your full attention to your observations. Stay in the house for somewhat longer at regular times and observe the birds. They will only show normal behaviour once you have settled for a few minutes.

How is uniformity in the flock? Are there differences between hens? How do they behave around each other and when they are about to lay?

How are the hens eating?

Take a good look at the colour and consistency, and assess if there is any odour coming from the droppings.

Then check the eggs. What stands out? Are there colour differences? Are there abnormalities on the eggshells? Break a few eggs open.

How is the yolk colour? How does the egg smell? Can you see anything abnormal?

If you have noticed any abnormalities, are they coincidental occurrences or a signal of a broader, underlying problem. Always look for connections between what you observe about the eggs and what that tells you about the hens or their environment.

Listen consciously by the house door before you enter the house. When you enter, the hens will react to you, so that you will not hear the noises they make when left undisturbed. And do not turn up the light right away. Light also influences their behaviour.

Observation in different ways

There are various ways to collect information about your hens and eggs. You can observe from a distance or close-up. You can use all your senses: look, feel, listen, smell, and you can even taste an egg. You can also use technology to collect data. Hand held candling lamps, candling units, electronic eggs can help to identify problems on the farm. Automated detection systems that work with sound or spectral analysis are used by grading machinery to detect dirt, cracks, leaking eggs, blood inside eggs, or changes to shell colour. Use technology to enhance what your own senses can tell you; to rely on only one or the other is to miss half of the picture.

You can only evaluate things that you notice in detail when you consider them in context. This is why you look from the eggs to the chickens, and from chickens to the flock. Sometime you have to take a step back, literally, so that you can observe something better.

Points of attention

Birds at risk

You can always pick out some poorer quality birds in a flock. These individuals do not produce many eggs and have poor disease resistance. They will also be the first to get sick, and that makes them good sources for early signals of illness in the flock. If the weaker birds become sick, this can be a sign of more to come.
Consider which birds could be most at risk on your farm, what problem they might present, and how you can use them to react to developing problems in good time.

Risky times

There are also specific times that have intrinsic risk. One of the well-known risky times is the period when young point of lay hens start laying for the first time. For example, if hens start laying too early, it is often reflected in the eggshell quality. Also if there are not enough nests available, this will result in too many floor eggs. Also, the moment of egg collection is a risky time.

Risky locations

And finally, there are risky locations, where you can expect problems, on every egg producer's farm. You need to check these locations every day and minimise the risk of a problem developing. Overcrowded nests or the egg conveyor belt are good examples of risky locations.

Transfer points in the egg transport are a risk place. Each transition leads to extra cracks and leakers. Focus on making transitions as smooth as possible.

Young hens coming into lay are potentially a risk group. They need to take up sufficient calcium to start laying eggs with strong eggshells. So, make sure that they get enough!. In this case there are calcium blocks set out in the house.

Here you can see birds piling up against a mesh door. Opening the door a couple of times a day, can be suffice to chase the birds back into the main space. But try to find a more permanent solution.

Unexplained matters

Sometimes you may observe small changes you do not understand immediately. If that is the case, and you notice there is a recurring pattern, try to work out possible explanations. You will learn from your mistakes, but also by experimenting to see what improves the situation i.e. what factors lead to successful elimination of the problem.

Unexpected matters

Sometimes, during your work, something suddenly pops up without you making any structured observations. It is important that you stay alert for such occurrences. Take action immediately or record it right away, so that you will be able to handle it later.

Turning on the feed chain is a period associated with risk. The hens can be come stressed by the event and can become uneasy if the feeders are turned on at different times each day. Stress leads to lots of egg abnormalities.

LOOK-THINK-ACT

Test yourself: which egg comes from which chicken?

You can recognise the chicken from her egg. Do you know which egg characteristic belongs to which hen?
Look at page 159 for the answer.

CHAPTER 2:

The egg

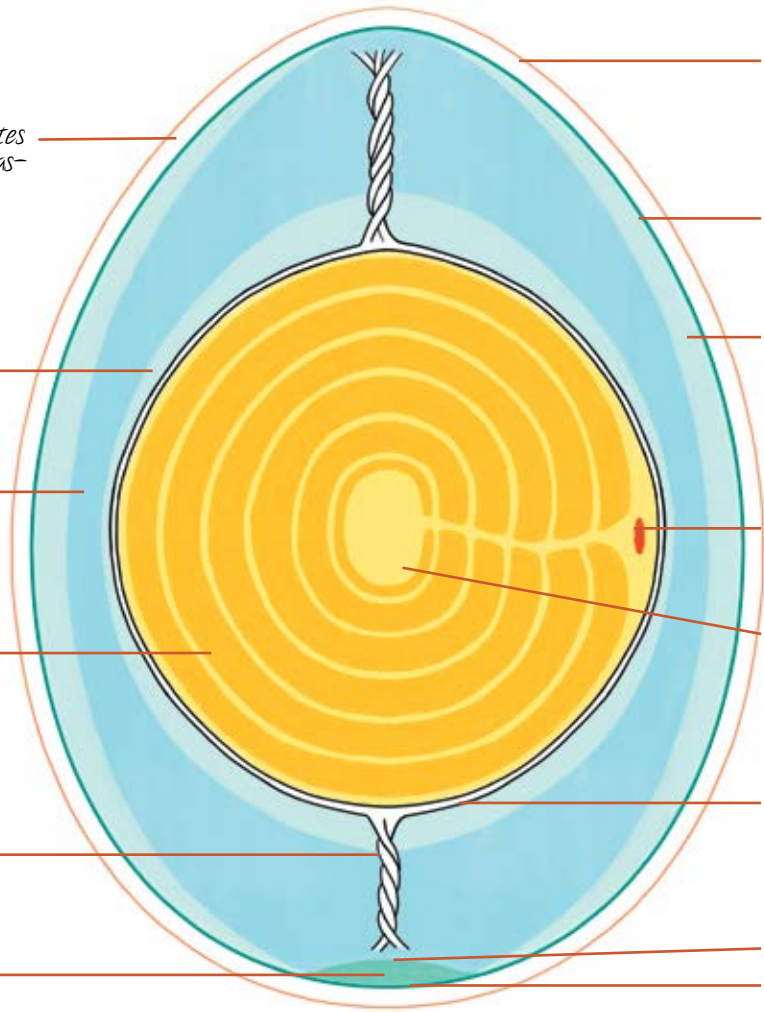
A chicken egg is a fantastic and complex entity, in which every part has a function, whether that is structural or nutritional. The entire entity is set up to produce a chick. When it comes to egg quality, it is vital to have a good knowledge of the parts of the egg and how it is formed.

A boiled egg is one of the most versatile and complete food sources. It is easy to digest, and needs hardly any processing to allow the human body to absorb it fully.

All the raw materials needed to form a chick are in the egg. The package includes carbohydrates and fats as an energy source, cholesterol in the yolk as a basis for cell wall and neural pathway formation, and protein as the building blocks for the body. From the twelfth day, the chick even starts taking calcium from the shell to form its bones. There are even substances in the egg to protect the chick against bacteria and viruses.

An egg is not only good for a chick; it is also a foodstuff that satisfies human nutritional requirements.

The components of an egg



Eggshell – protects the egg contents and regulates air exchange through gaseous exchange pores.

Inner thin albumen (white) – between the yolk and the thick albumen.

Thick albumen (white) – a nutritional and water source for the chick, has antibacterial properties and acts as a shock absorber.

Yellow yolk – provides remainder of the nutrition for the chick.

Chalazae – twisted structures derived from the albumen which hold the yolk in the centre of the egg.

Air chamber – (also called air cell) the space between the inner and outer shell membranes.

Cuticle (bloom) – protects the egg contents by sealing off the gaseous exchange pores which run through the shell.

Shell membranes – provide protection against dangerous bacteria and form a base layer for shell formation.

Outer thin albumen (white) – the layer between the thick albumen and the eggshell membranes.

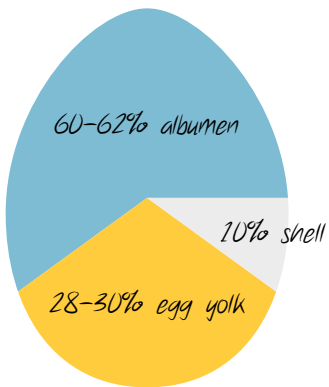
Germinal disc – this is where the chick develops after fertilization.

White yolk – the initial food source for the developing chick, is quite different in composition to the yellow yolk.

Yolk or vitelline membrane – forms a barrier between the yolk mass and the albumen.

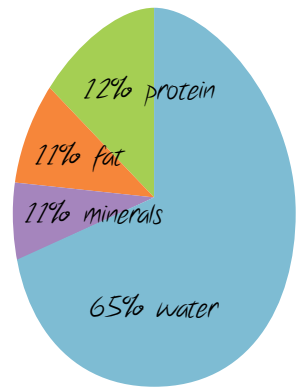
Inner shell membrane

Outer shell membrane



Egg composition

An average egg weighs around 60 grams and consists of about 60% albumen, 30% yolk, and 10% shell. White eggs generally contain more yolk.



Chemical composition

The main chemical components of an egg are water, proteins, fat and minerals. Brown eggs have slightly higher water content, and thus lower dry matter content than white ones. This difference is determined genetically.

Nutritional value of eggs

Eggs stand out very positively when compared to other sources of animal protein. When it comes to nutritional value, an egg lies between milk and beef. There are a lot more unsaturated fats in an egg, which are considered to be healthier. The saturated fat level in an egg is less than in milk.

Protein helps weight management

Proteins satisfy hunger more effectively than other nutrients like carbohydrates or fat. In other words it takes longer for a person to become hungry again after a protein rich meal. Also fewer calories are consumed at a meal if the previous meal had a high protein content. This is why proteins can play a role in weight management.

Composition of specific parts

	Albumen	Egg yolk
Water	88%	48%
Proteins	11%	17.5%
Fats	0.2%	32.5%
Minerals	0.8%	2%

Source: ABN AMRO and Blonk Milieuadvies

When it comes to nutritional value, eggs come between milk and beef in the ranking.

A comparison of nutritional value of milk, eggs and beef

Nutritional value	Milk, per 100 g	Egg, per 100 g	Beef, per 100 g
Energy	62 kCal/261 kJ	144 kCal/602 kJ	279 kCal/1169 kJ
Proteins	3.7 g	12.5 g	30.0 g
Carbohydrates	4.3 g	1.1 g	0.7 g
• of which sugars	4.3 g	0.2 g	0.0 g
Fats, of which:	3.4 g	10.0 g	17.5 g
• saturated	2.1 g	2.5 g	7.5 g
• monounsaturated	0.9 g	3.0 g	7.0 g
• polyunsaturated	0.1 g	1.8 g	1.0 g
Cholesterol	9.5 mg	350 mg	60 mg

Source: Dutch nutrition centre

Did you know?

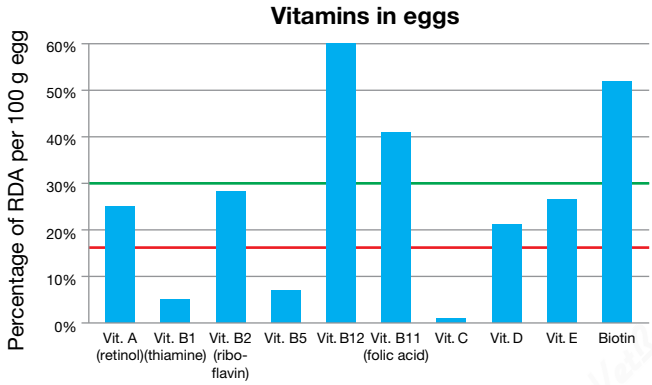
The protein in a raw egg has 55% bio-availability. Boiling increases that level to 91%. That means a boiled egg absorbs almost twice as well as a raw egg. This is why body builders who eat eggs to build up strong muscles are better off boiling them first!

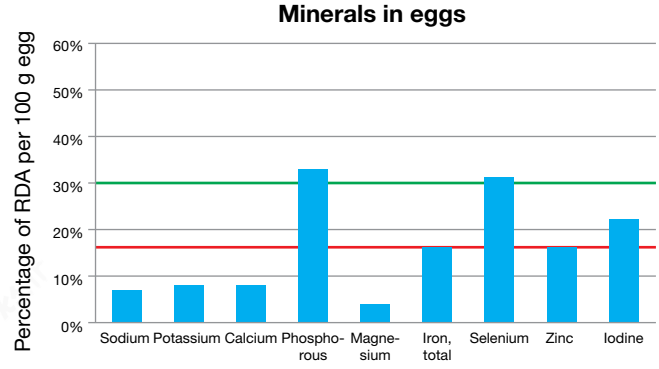
A source of vitamins and trace minerals

Eggs contain almost all of the vitamins except vitamin C. Eggs are rich in vitamins A, D, E, and several B vitamins, including B12. An egg is also rich in phosphorus and selenium, and is a good source of iron, zinc, and iodine. All these vitamins and trace minerals are available in a form that is easy to absorb.
Their high protein, iron, and vitamins A and B content make eggs a very good alternative for meat.

Woman (117): ''The secret of getting old? Avoid men and eat eggs!'

Emma Morano is the oldest living person in Europe in 2016; she is 117 years old! Emma spent years following the advice that a doctor once gave her 'eat three raw eggs every day'. She must have eaten about 100,000 raw eggs during her lifetime! Emma lived alone ever since her first marriage came to an end in 1938. In her opinion, both of those factors helped her to reach such a grand old age.





Vitamins and minerals per 100 grams of egg, in relation to the recommended daily allowance (RDA). Vitamin B12 (formation of red blood cells, and nervous system function) and biotin (energy metabolism, skin and hair) are available in large quantities. Eggs are also a great source of phosphorus and selenium. Phosphorous is important for bones and teeth, and for energy metabolism. Selenium is an antioxidant that contributes to the shelf life of the egg. Selenium is also important for the immune system and muscle development.

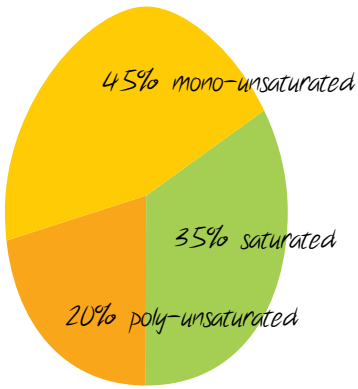
Vitamins and minerals in milk, eggs and beef

Nutritional value	Milk, per 100 g	Egg, per 100 g	Beef, per 100 g
Vitamins			
Vit. A	0.03 mg	0.20 mg	0.03 mg
Vit. B1	0.03 mg	0.10 mg	0.02 mg
Vit. B2	0.17 mg	0.30 mg	0.06 mg
Vit. B6	0.04 mg	0.15 mg	0.15 mg
Vit. B11	4 µg	60 µg	5 µg
Vit. B12	0.04 µg	2.30 µg	3.50 µg
Vit. C	2.0 mg	0.0 mg	0.0 mg
Vit. D	0.1 µg	1.8 µg	0.7 µg
Minerals			
Sodium	44 mg	120 mg	100 mg
Potassium	160 mg	130 mg	400 mg
Calcium	120 mg	50 mg	10 mg
Phosphorous	99 mg	180 mg	200 mg
Iron	0.0 mg	1.8 mg	3.0 mg
Magnesium	10 mg	10 mg	30 mg
Copper	0.01 mg	0.08 mg	0.08 mg
Zinc	0.50 mg	1.30 mg	7.00 mg

Unsaturated fats

Around 10% of an egg consists of fatty acids, which provide about 60% of the energy within the egg. You need fatty acids originating from unsaturated fats for good cell formation in the body and good resistance. Unsaturated fats occur also in fish, nuts, mayonnaise, and some vegetable oils (olive oil). These fats are essential, because humans cannot make them.

Different types of egg (aviary run, corn fed, or organic) may differ slightly in nutritional value. This is the result of the nutrition and health of the laying hens, which directly affects the egg's composition.



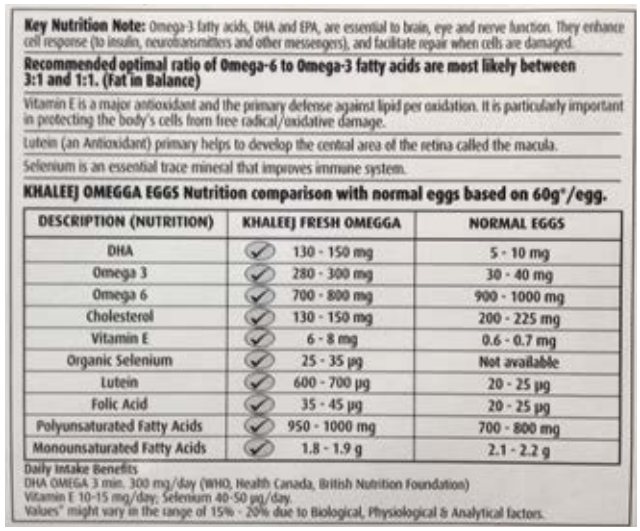
Fatty acid composition in an egg.

Enriched eggs promote health

Omega-3 fatty acids are polyunsaturated fatty acids (first double bond in the third position, hence the 3 in the name) and have been found to protect against cardiovascular disease. The best-known omega-3-fatty acids are the vegetable alpha linolenic acid (ALA), and the fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These omega-3 acids are better absorbed from eggs than from direct consumption (via pills from a pharmacy).

Hens fed with feed enriched with special ingredients, such as linseed (ALA, see the picture), fish oil, or algae (DHA and EPA) lay special enriched eggs. The chicken absorbs the unsaturated fat from the feed and converts it, in a natural way, into extra omega-3 fats which are incorporated into the egg.

Consumers are sometimes willing to pay extra for eggs which have been enriched with omega-3 fatty acids because of their added value. The taste of omega-3 enriched eggs may deteriorate unless properly kept in the refrigerator.



Key Nutrition Note: Omega-3 fatty acids, DHA and EPA, are essential to brain, eye and nerve function. They enhance cell response (to insulin, neurotransmitters and other messengers), and facilitate repair when cells are damaged.

Recommended optimal ratio of Omega-6 to Omega-3 fatty acids are most likely between 3:1 and 1:1. (Fat in Balance)

Vitamin E is a major antioxidant and the primary defense against lipid per oxidation. It is particularly important in protecting the body's cells from free radical/oxidative damage.

Lutein (an Antioxidant) primary helps to develop the central area of the retina called the macula.

Selenium is an essential trace mineral that improves immune system.

KHALEEJ OMEGGA EGGS Nutrition comparison with normal eggs based on 60g*/egg.

DESCRIPTION (NUTRITION)	KHALEEJ FRESH OMEGGA	NORMAL EGGS
DHA	✓ 130 - 150 mg	5 - 10 mg
Omega 3	✓ 280 - 300 mg	30 - 40 mg
Omega 6	✓ 700 - 800 mg	900 - 1000 mg
Cholesterol	✓ 130 - 150 mg	200 - 225 mg
Vitamin E	✓ 6 - 8 mg	0.6 - 0.7 mg
Organic Selenium	✓ 25 - 35 µg	Not available
Lutein	✓ 600 - 700 µg	20 - 25 µg
Folic Acid	✓ 35 - 45 µg	20 - 25 µg
Polyunsaturated Fatty Acids	✓ 950 - 1000 mg	700 - 800 mg
Monounsaturated Fatty Acids	✓ 1.8 - 1.9 g	2.1 - 2.2 g

Daily Intake Benefits
DHA OMEGA 3 min. 300 mg/day (WHO, Health Canada, British Nutrition Foundation)
Vitamin E 10-15 mg/day; Selenium 40-50 µg/day.
Values* might vary in the range of 15% - 20% due to Biological, Physiological & Analytical factors.

This special label for omega-3 eggs highlights the added value compared to regular eggs very clearly.

The egg as a medicine: lutein

Lutein and zeaxanthin are carotenoids which can have a beneficial effect on eye disorders, particularly for macular degeneration. Macular degeneration, often referred to as 'wear and tear' of the retina, is caused by factors including exposure to ultraviolet radiation from sunlight and ageing. Lutein and zeaxanthin protect the eyes from ageing and harmful radiation from sunlight, acting like natural sunglasses. Broccoli, kale, corn, and eggs contain lutein. But you would need to eat two kilos of vegetables a day to absorb sufficient lutein. Enriching eggs with lutein (and zeaxanthin), makes it much easier.

The big advantage with eggs is that these substances are in solution in the fats, and are thus easily absorbed through the intestine.

Macular degeneration

Macular degeneration is an irreversible form of damage to a part of the retina. Seeing fine details becomes increasingly difficult. The upper image is from a person with normal sight. The lower image is how a patient with macular degeneration would see this picture.

Fruit and vegetables contain yellow and red natural colourings, carotenoids. Carotenoids work as antioxidants and the body can convert some of them into vitamin A. Our body cannot take up all the carotenoids from fruit and vegetables. It can do that successfully when you eat whole eggs (boiled or scrambled) in the same meal. So, eggs in your salad are extra healthy.

Lutein content in eggs can be raised by adding a lutein supplement to the hens' feed. The marigold (Tagetes erecta), is one plant that contains lutein. Poultry feed supplement suppliers work lutein extract from marigolds into their products.

A health risk?

Eggs are not always in the news for positive reasons. Sometimes justly, but very often not. Consider all the fuss that there was about cholesterol. Some stories however do have a sound basis as sometimes unwanted materials can get into eggs, e.g. dangerous substances like PCBs and dioxins.

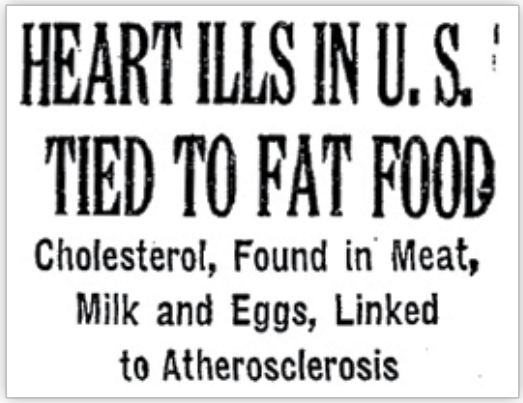
Cholesterol – from good to bad to good again!

In the late nineteen-sixties, we were advised not to eat too many eggs because we would consume too much cholesterol. Cholesterol was thought to be harmful to our body because, in combination with other risk factors, to increase the chance of suffering heart and vascular diseases. But more recent research has shown that there is no connection between dietary cholesterol and increased cholesterol levels in the blood, putting eggs back on the safe list.

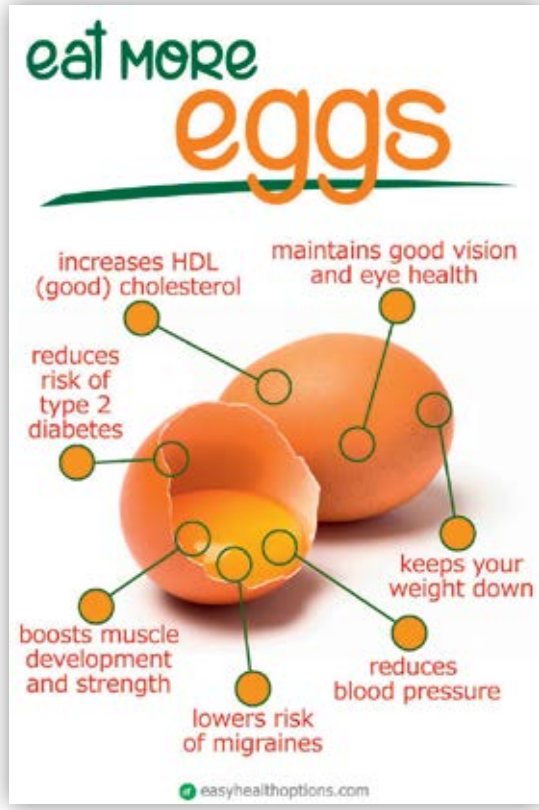
The cholesterol levels in our body are influenced by other factors, which include certain saturated fats and trans fats. Full fat milk products and cheeses, red meat, pastries, and snacks are all examples of foods that contain saturated fats and trans fats. Most of the fat content in eggs consists of unsaturated fats.

In addition, there is a difference between good cholesterol (HDL, High Density Lipoprotein) and bad cholesterol (LDL, Low Density Lipoprotein). Good cholesterol from unsaturated fats breaks down the bad cholesterol originating from saturated fats, and in that way helps to reduce blood cholesterol levels. An egg has a particularly low saturated fat content and is rich in unsaturated fats, which all helps to reduce the risk of heart disease. So the story is actually the other way around than presumed before.

In 1984, eggs featured on the cover of Time Magazine, as an enemy to our health. In 1999, the accepted opinion was exactly the opposite!


HEART ILLS IN U. S. !
TIED TO FAT FOOD
Cholesterol, Found in Meat, Milk and Eggs, Linked to Atherosclerosis

In 1956, there was an article in the New York Times about the negative health effects of the cholesterol associated with eggs.



Currently, the opinion is much more positive. Promotion of the health benefits of egg by the egg industry plays an important role here.

Negative aspects: Dioxins and PCBs

Dioxins are bad for the immune system, brain development and reproduction, and higher doses can lead to cancer. Dioxins do not break down well, and they build up in body fat, where, through the blood, they pose a threat for other tissues. Dioxins are formed when plastics are burned, but they also occur naturally in certain types of clay, e.g. kaolinite.

PCBs have comparable poisonous properties. PCBs are used in insulation, hydraulic, and coolant fluids, lubricants, as a fire retardant and as a stabiliser in the manufacture of plastics. They were also found in paints and glues. Currently, PCBs are banned, but their poor degradability means that there are still a lot of PCBs in the natural environment (in substrate and silt.)

Chickens can take up dioxins and PCBs from their feed, but the risk is higher when they ingest contaminated soil. These substances can build up in their meat and eggs. Preventative measures:

- Remove the substrate layer and replace it with clean sand or soil. Lay tiles. Clean the pen regularly.
- Feed the chickens from a feeding tray. Do not scatter any feed in the outdoor run. Make sure your hens have enough feed, so that they will not eat so many worms contaminated with soil.
- Remove re-used building waste or ash from the outdoor run.
- PCBs can also originate from old paint, insulation sealants or roof coatings that can be leached out by rain. Fit rainwater gutters and remove and replace old paint layers from the house and run.

LOOK-THINK-ACT

Are dioxins only found in heavily contaminated ground?

These hens ingest soil. Eggs from free range chickens may have higher levels of dioxins and PCBs, because the main source of contamination is contaminated soil. A relatively low dioxin and PCB content in the soil can still lead to increased levels in the eggs. Thus, the problem is not usually a result of heavily contaminated soil. That is why you need to ensure that the ground in the run is really clean and that the hens have their feed provided in trays rather than scattered on the ground. The fact that they have a free outdoor run, means that organic eggs actually risk having higher levels of these contaminants.

LOOK-THINK-ACT

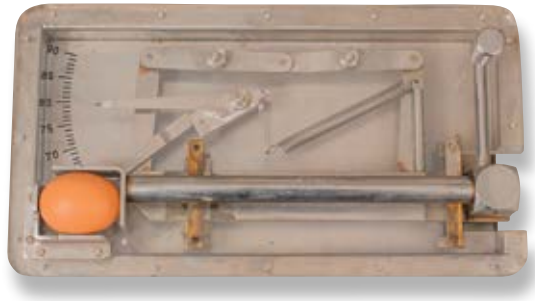
Why does this pose a risk?

A feed chain needs lubrication for smooth running, but watch out! Dioxin or PCBs can hide in unexpected places, e.g. in the lubricant used on the feed chain, in wood shavings, in the packaging on bales of lucerne (alfalfa), and in old waste materials worked into the ground in the outdoor run. Even new materials can be contaminated, e.g. through use of an incorrect coating. You should be aware of what materials could pose a risk for dioxin of PCB contamination.

Shape makes a strong egg

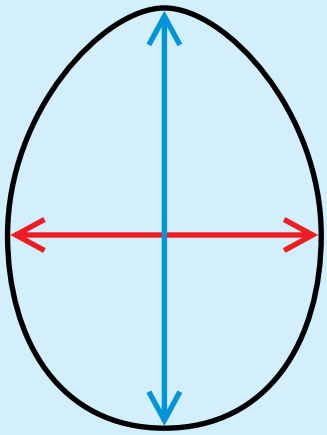
Besides being a naturally convenient pre-packaged food, eggs also come in a very strong packaging. The strength does not only come from the shell's composition, the shape also plays an important role. It is not round, it is egg shaped! The arched structure gives an egg extra rigidity.

Egg shape (round to cigar-shaped) is determined genetically, and thus dependent on strain. Both elongated eggs and round ones are weaker, which makes such extremes in shape undesirable.



The shape index is not used in practice as a quality characteristic, only in research and breeding. Old-fashioned shape index meters like this one belong in a museum.

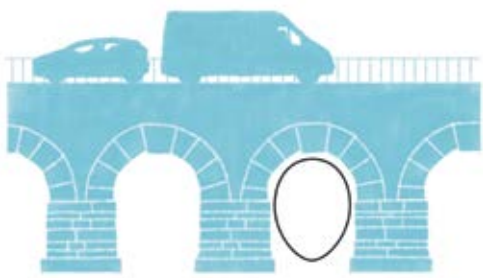
Calculating shape index



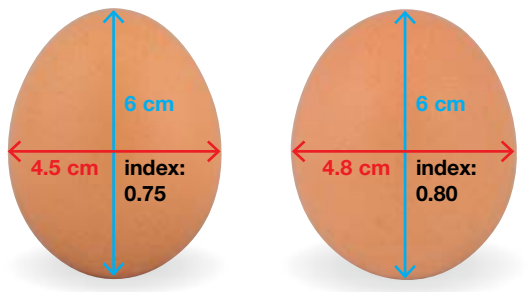
Egg shape is expressed objectively as a 'shape index'. You calculate this by measuring and dividing the width of the egg by its length. The ideal egg has a shape index of 0.765. 99% of all eggs have a shape index of between 0.69 and 0.85. If the shape index is under 0.72, the egg is too long and thin. If the shape index is higher than 0.76, the egg is too round.

A double yolker is an XXL egg, and you can sometimes recognise one by its almost 'square' form with two identical rounded ends.

Eggs of younger hens are often longer and more pointed. Eggs of older hens are more often rounder and thicker. This egg has a shape index of 0.55.



An egg has an arched curved shape. An arch curved shape can take powerful forces. The Romans discovered that very long ago. They used arches to build very strong aqueducts and bridges.



A round egg will break in plastic trays quicker. During recent decades, it seems that eggs are continuing to get rounder. While the average shape index was 0.73 in 1980, it is currently 0.75.

Weight distribution in eggs

Egg weight varies through a hen's laying cycle. Young hens lay smaller eggs, and they become progressively larger as the bird ages.

Brown size Medium (M) and Large (L) eggs sell as table eggs in European supermarkets. White size M and L eggs go mainly to the processing industry. Size Small (S) eggs are sold in some supermarkets as 'pullet eggs', and for a higher price than regular ones. You do not see XL eggs very often in supermarkets; they mainly go to the processing industry or for direct sales..

Egg pricing

Big eggs are good for processing, because you have more content from breaking the same number of eggs. Eggs for industry are thus paid in terms of total weight (kg). In the case of table eggs, it is a matter of the number of eggs and their weight class.

The poultry farmer receives a reduced price for second grade eggs.

Weight classification of eggs

Categoría	Peso	
	Europe	USA
Jumbo		> 2.5 oz. (70.9 g)
Extra Large (XL)	> 73 g	2.25 - 2.5 oz (63.8-70.9 g)
Large (L)	63-73 g	2 - 2.25 oz (56.7-63.8 g)
Medium (M)	53-63 g	1.75-2 oz (49.6-56.7 g)
Small (S)	< 53 g	1.5-1.75 oz (42.5-49.6 g)
Peewee		1.25-1.5 oz (35.4-42.5 g)

A scale that was used in the past for classifying eggs (left) and a modern digital scale (right). Eggs are heavier at the end stage of a production cycle.

Quality requirements for the table egg

In summary, a good quality, fresh egg has an elliptic shape with a clean, smooth, and shiny shell surface. The shell must be intact, free of hairline cracks or other defects (which may cause the egg to break during cooking). The egg colour should be even. In terms of content, the egg white must be clear, jelly-like, and layered. There should not be any inclusions, such as blood or meat spots. The egg yolk must also be evenly clear yellow to dark yellow, and should be anchored in the centre of the egg. The egg content must also be odour free and not be contaminated with microorganisms.

Objective quality assessment

Payment systems are based on expected or desired quality criteria. Variations from the standards are subject to punitive price reductions. This is dependent on the flock's age. It is logical that eggs from an older flock will be heavier than those from young birds, but if the ones from a younger flock fall into a too heavy weight class, the flock will get a poor assessment.

Assessment criteria

Criterion	Assessment
Average weight	Eggs become heavier as the hen ages. If eggs are heavier than expected for the age of the hens, you will get a lower quality assessment (this is a separate matter from the actual weight classification).
Yolk colour	The desirable colour, which you can control through feed, is subject to agreement. Any excessive variation in this will result in a lower quality assessment (1 point variation = moderate, 2 points difference = poor).
Breaking strength	This is measured in Newtons. The breaking strength is higher with young flocks than older ones due to the shell thickness. If the breaking strength is less 36, it is considered moderate, 34-Newton is assessed as poor.
Haugh Units	Haugh Units (HU) are a measurement of egg freshness (but it is, in principle, determined through the protein in the feed and hen health). The HU decreases with the age of the hens and length and conditions of storage.
Air chamber	The size of the air chamber should be even throughout the production cycle. Storage conditions and the length of storage have a great deal of influence on this parameter. An air chamber depth of 2 mm is good, 3 mm moderate, and 4 mm poor, for eggs that are less than 10 days old.
Dirty shells	The criteria on this remain the same throughout the production cycle. The ideal is 0%, more than 1% dirty eggshells is considered moderate, and more than 2% is poor.
Leakers/spilled egg contents	Clearly observable cracks, where the eggshell membranes are broken. Incidence increases slightly with hen age. Where 3% is considered merely moderate with young hens, it is seen as good for older birds.
Hairline cracks	Invisible cracks in the eggshell. After two days, easy to see with a candling lamp. More hairline cracks appear as hens age.
Glassy, pointy eggs (GPE)	The ideal is 0%, more than 1% is considered moderate, while 2% is poor.
Total second grades	This a combined rating of dirty eggshells, leakers, and hairline cracks The assessment of this rating changes during the production cycle. In the beginning of a production cycle, less than 1% is considered good and 4% is poor, while 5% is assessed as good toward the end cycle and more than 10% as poor.
Separately delivered second grade	A higher percentage of second grade eggs is accepted as the duration of the production cycle progresses.
Printed data on the egg	The printing on the egg must be correct, complete, and easily legible.
Age	The age of the birds is stated on the package slip, to allow assessment of the criteria mentioned earlier.
Remarks	Besides these objective assessments, additional remarks may be added to the egg purchasers' reports.

Abnormal odours

Eggs themselves do not smell very much, but sometimes they can have a very strange odour. This may be caused during the egg production, but it can also be caused by the consumer.

If fish meal, choline and oilseed products are used in the feed sometimes this can change the odour of eggs. The cause can also be found in the poultry house. Wood chips from trees that originated from Brazil and were treated against rot, appear to give a musty odour to the eggs. This was a problem related to floor systems and unknown in cage systems.

Eggs also easily absorb odours from other products. This is a good reason not to store eggs in the same place as onions, garlic, or fish. Eggs contaminated with bacteria will also have a different odour.

A fishy smell

Sometimes you notice that eggs have a fishy smell. That can be caused by trimethylamine (TMA) in the egg yolk. TMA is a breakdown product from natural precursors such as choline (highly present in rape seed). In healthy animals TMA is absorbed and converted. In hens that carry a certain genetic factor the enzymes to convert TMA are not working properly. There is a DNA test that can detect this defect in chickens, which allows the breeding companies for selective breeding. Currently most commercial strains are bred to be TMA free.

If there is more than two per cent fish meal in the feed, you might be able to smell it in the egg.

Abnormalities and how to prevent them

Egg signal	Characteristics from the report	Causes and actions (now or with the next flock)
Too light or too heavy	Average weight	Check the amount and type of laying hen feed. Ensure point of lay pullet weight is optimal. Check recommended lighting program was followed at point of lay- too early or too late.
Too light or dark colour	Yolk colour	Modify the amount of red and yellow colour additives in the feed, Check the amount and type of laying hen feed. Check birds general and gastrointestinal health.
Weak shell	Breaking strength	Check the amount and type of laying hen feed – calcium levels? Seek technical guidance. Change choice of strain. Check house temperature- high environmental temperatures reduce feed intake. Check flock health status.
Thick albumen too low	Haugh Units (HU, freshness)	Change the quantity of protein in the feed. Ensure the flock has IB protection. Check the general health of the flock. Remedy excessively high storage temperatures.
Shell colour too pale	Shell colour (only brown eggs)	Change the choice of strain. Reduce bird exposure to influence from sunlight (especially with bald chickens – Free range). Check for use of medications that effect shell colour (e.g. nicarbizin).
Dirt on the eggs (including droppings, dust, mites, or fly faeces)	Dirty shells	Ensure nest boxes are clean and not worn-down. Check the amount and type of laying hen feed. Check hen health. Check egg belt speed. Check house climate (especially relative humidity, RH).
Too many cracked eggs	Too many dented eggs (star dents, the membrane still intact)	Check the farm's egg collection system, or remedy low breaking strength.
Too many eggs with hairline cracks	Hairline cracks (invisible to the naked eye, eggs burst during boiling)	Check the farm's egg collection system, or remedy low breaking strength.
Too many open cracks	Open cracks/leakers	Prevent hens from pecking eggs. Check the farm's egg collection system, or remedy low breaking strength.
No stamp/print, wrong code, or not legible	Egg stamp	Ensure that the egg stamping machine or ink jet printer is well set up and maintained.

CHAPTER 3:

The chicken

Egg formation takes a total of twenty-four hours.

A chicken will naturally lay an egg, even if it's not fertilised. The number of eggs she lays and their weight are factors that you can influence through your choice of strain and management. Production of 320 eggs per year is a normal target to achieve. Targeted breeding of chickens for egg production began in the seventeenth century, and the process accelerated remarkably just after the Second World War.

Over thousands of years, wild jungle fowl developed into the modern chicken, the red jungle fowl (Gallus gallus) is one example. Hens of that breed lay six to ten eggs per clutch.

Joseph Wolf (1820-1899)

A hen's reproductive system begins to develop when she is 16 weeks of age. At around twenty weeks, the hen will produce her first egg.
In contrast to other animals species (such as the cow), a hen does not have to be fertilised in order to lay eggs. So cockerels are not necessary for egg production.
Peak production is when an egg is produced almost every day. This occurs at around the twenty-eighth to thirtieth week. You need very good management to maintain this level of production. Knowledge about the changing needs of the chicken is the foundation for that.

The hen's reproductive system

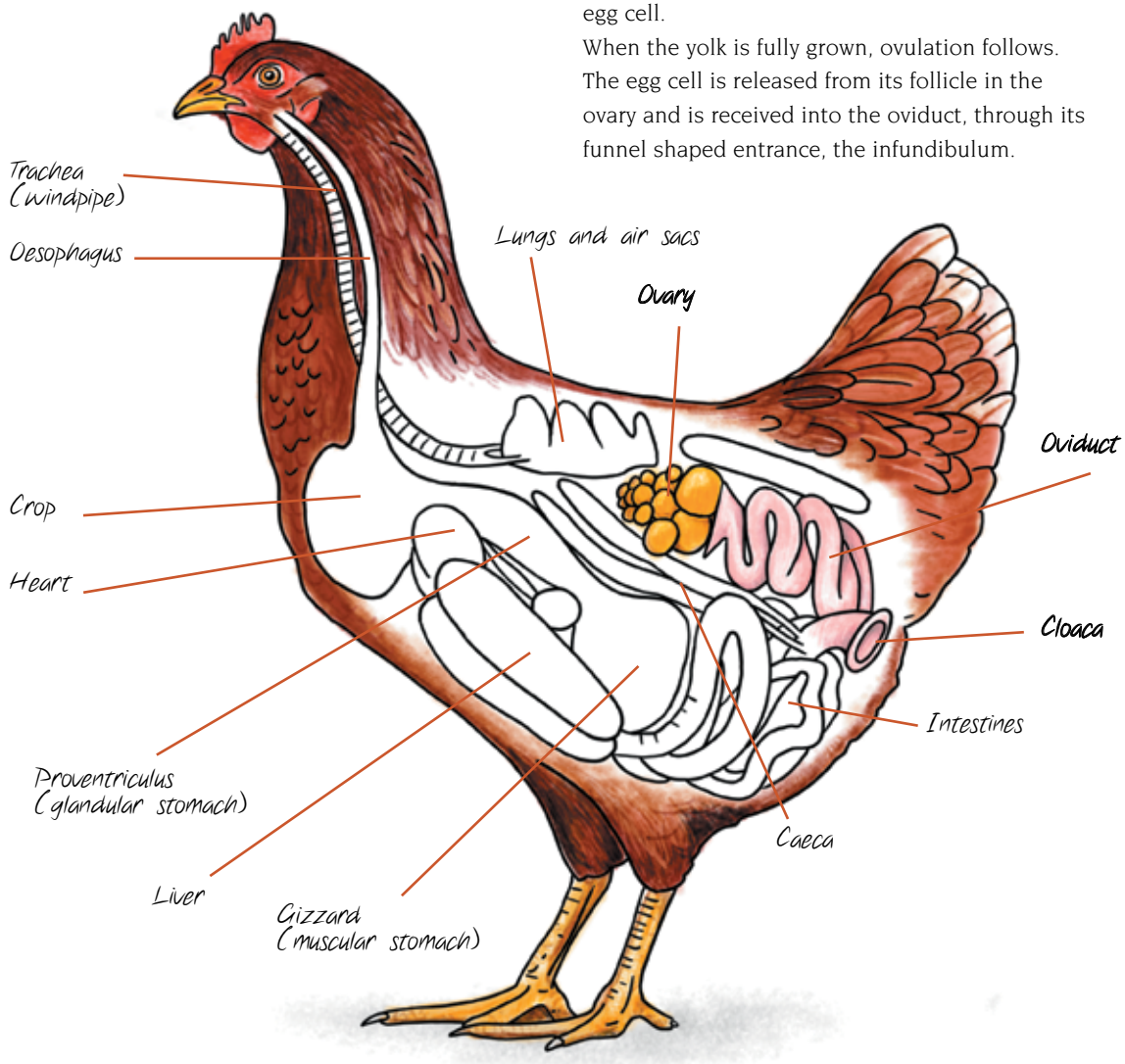
Each part of the hen's reproductive system plays its own role in egg formation. All the different processes are precisely tuned to each other in terms of sequence and duration.

The hen's reproductive system comprises two main parts: the ovary and the oviduct. In most female animals, both the left and right ovaries function, but in poultry, normally, only the left ovary and oviduct are active.

Ovary

The ovary in a hen is located high up in the body cavity half way between the neck and tail. This organ is already fully developed in a day-old-chick. It is shaped like a small bunch of grapes, and comprises between 3,600 and 4,000 mini egg cells (future egg yolks), each in its own little sack or follicle. Each sack is rich in blood vessels. At this stage each mini egg cell is comprised of a tiny yolk with a germ cell on it. When a chicken becomes sexually mature (strongly influenced by day length), the egg cells grow in the ovary into a full yolk. This takes about seven to ten days. In an active ovary there are about seven germ cells at different stages in the process. The fully grown yolk and germinal disk combined now form the egg cell.

When the yolk is fully grown, ovulation follows. The egg cell is released from its follicle in the ovary and is received into the oviduct, through its funnel shaped entrance, the infundibulum.



The reproductive organs lies against the hen's back.

Oviduct

The oviduct is a long tubular shaped organ, which is loosely attached to the backbone. The egg white, shell membranes, and the egg shell are formed in the oviduct. The oviduct runs right through to the cloaca. This is also where the urinary and gastrointestinal tracts empty into.

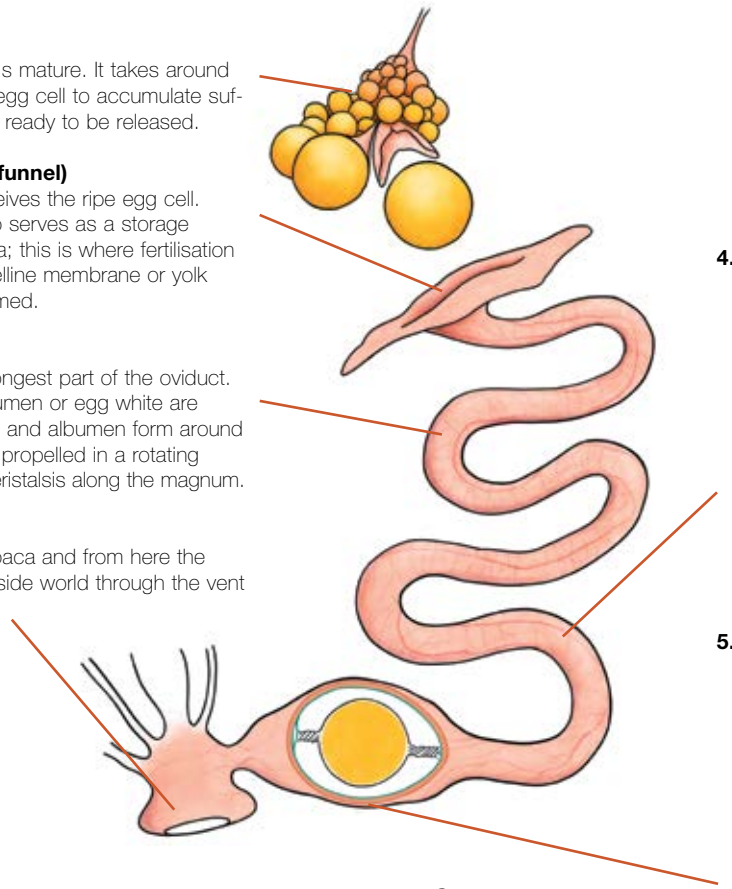
The oviduct is around 64 to 69 centimetres long. Different parts of it each have their own function in forming the components of the egg.
The reproductive system comprises six different parts:

1. Ovary
This is where egg cells mature. It takes around eight days for a mini egg cell to accumulate sufficient yolk for it to be ready to be released.

2. The infundibulum (funnel)
The infundibulum receives the ripe egg cell. The infundibulum also serves as a storage place for spermatozoa; this is where fertilisation occurs before the vitelline membrane or yolk membrane is fully formed.

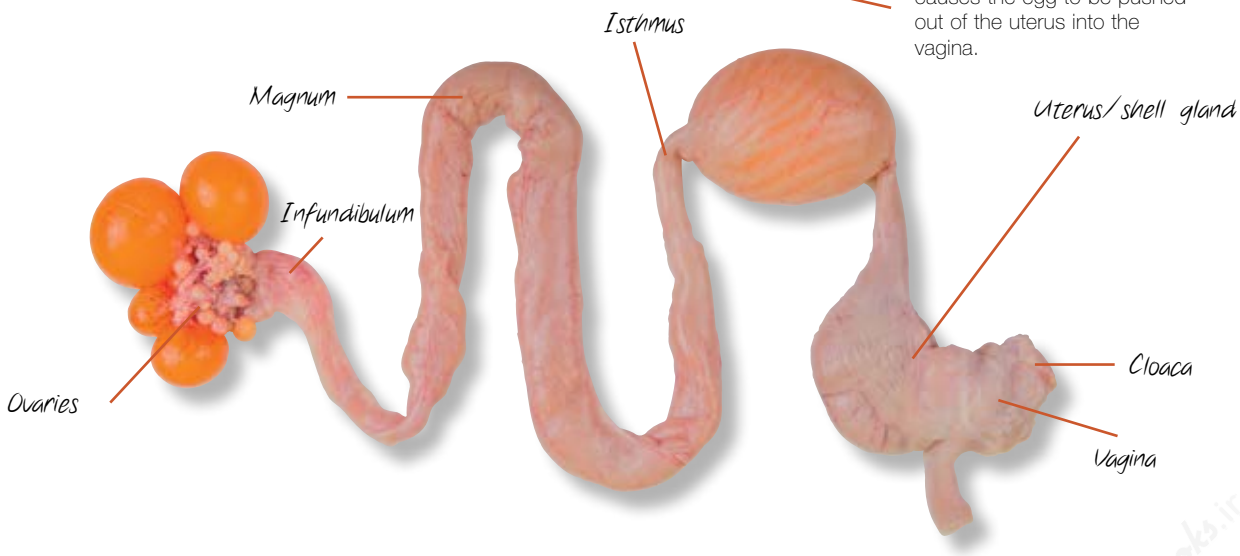
3. The magnum
The magnum is the longest part of the oviduct. This is where the albumen or egg white are formed. The chalazae and albumen form around the yolk mass as it is propelled in a rotating motion by rhythmic peristalsis along the magnum.

6. The vagina
Leads out into the cloaca and from here the egg exits into the outside world through the vent



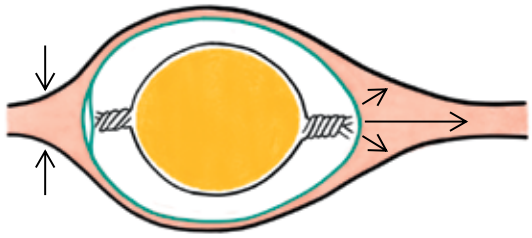
4. The isthmus
The two shell membranes, inner and outer, are formed in the isthmus. By the time the egg mass gets to the end of the isthmus, calcium salts have begun to be deposited onto the outer shell membranes, signalling the beginning of shell formation. The outer albumin becomes more fluid due to the addition of water and minerals during the early stages of shell formation.

5. The uterus/shell gland
The eggshell forms in the uterus over a period of twenty hours. At the end of shell formation, colour pigments are added to the shell. A hormone surge causes the fully formed egg to go through a 180-degree rotation. This causes the egg to be pushed out of the uterus into the vagina.

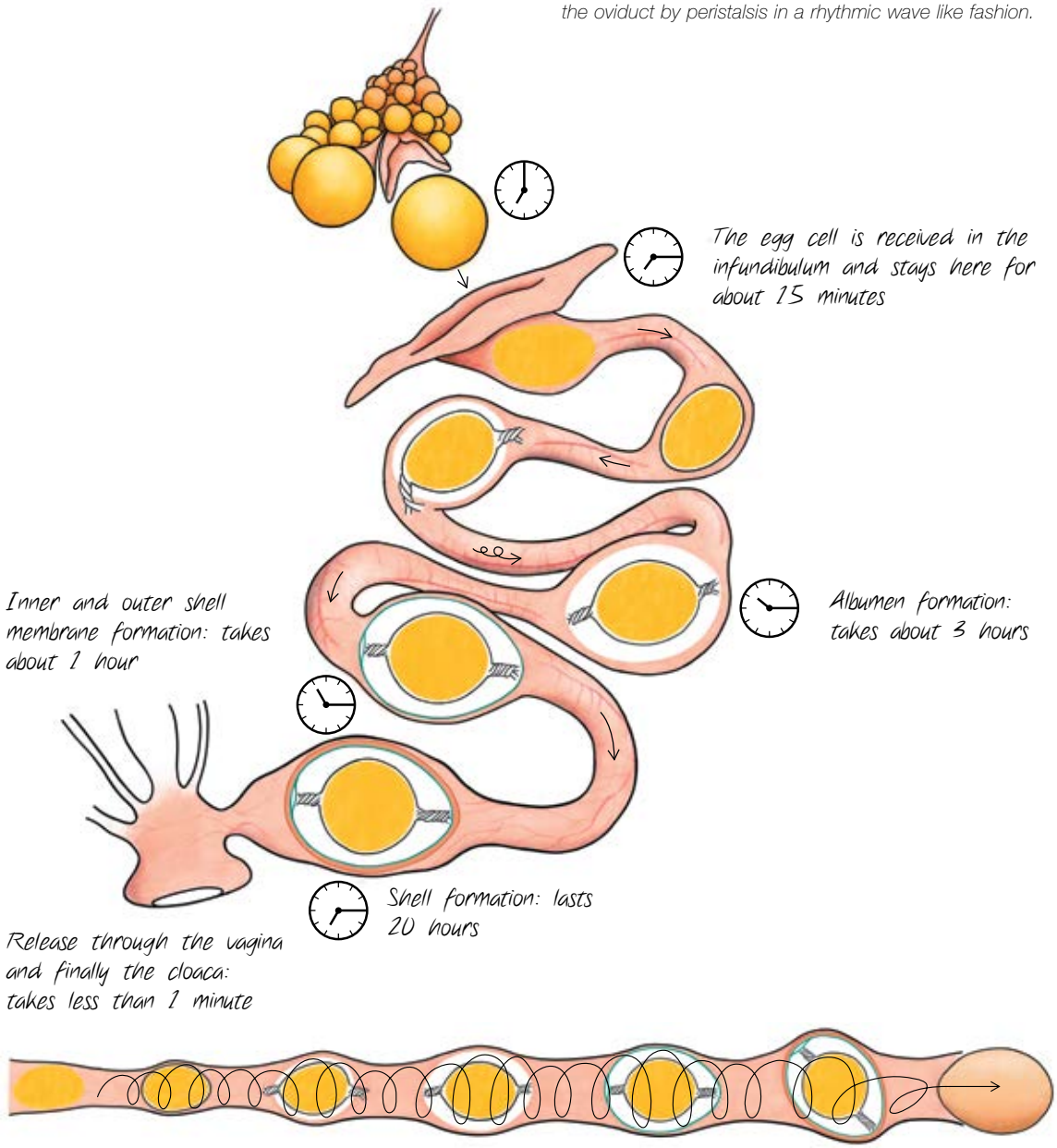


The passage duration of an egg

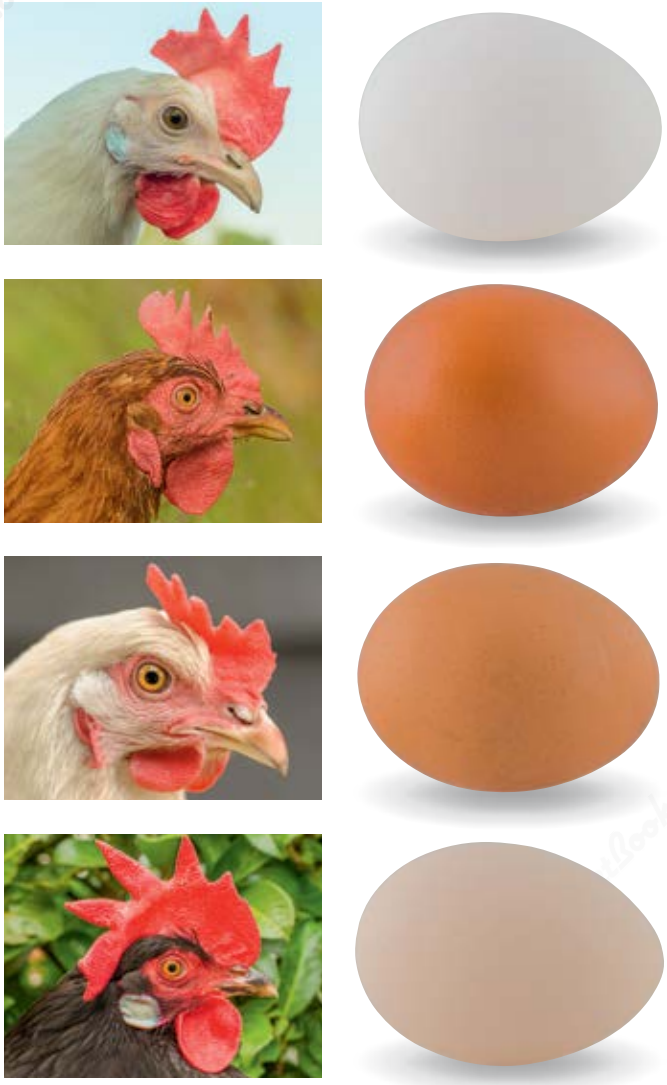
Egg formation takes a total of around twenty-four hours. The first part is relatively fast. Shell formation takes the most time. That is why most abnormalities in eggs are shell related.



Eggs travel through the oviduct with their points toward the direction of travel. This helps the egg to move along the oviduct by peristalsis in a rhythmic wave like fashion.



The egg turns continuously around its longitudinal axis (counterclockwise) as it passes through the oviduct. That is how the albumen and the shell form evenly around the yolk. Once shell formation is complete, as the hen prepares to lay the egg, the egg usually turns around in the uterus (or shell gland), so that it is laid blunt end first.



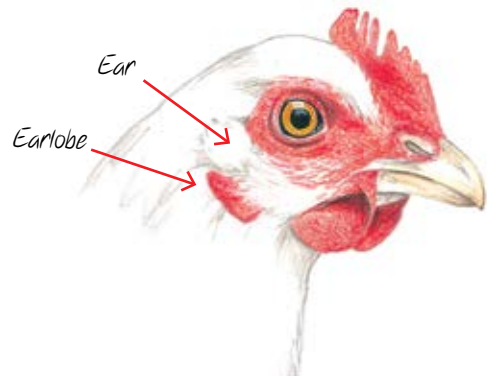
Shell colour is genetically predetermined. You can see it on the hen. Obviously, there are some other factors that affect shell colour, like diseases, but they are not determinative. An egg's colour does not tell you anything about the flavour or nutritional value.

Choice of strain and egg quality

The housing system, the preference for white or brown eggs, availability of raw materials, and the desired average egg weight are all determining factors for the choice of strain.

Most hens are bred mainly for caged housing systems. It's all about efficient production, which is fine tuned for a maize/soya diet in the USA.

It is not easy to adapt that type of chicken to another housing system and diet. You need different genetic predispositions for that. Hens for the European market have been bred for alternative housing systems for decades. Important goals for breeding are hardiness and good behaviour, so that the birds can handle variable situations, which arise more frequently in these types of system than they would in cages. These hens are often a little less efficient in production, because they lose more energy to activity and maintenance of a higher body weight.



A hen's earlobe gives a clue to the colour of her eggs. A hen with white earlobes, tends to lay white eggs. A hen with red earlobes, tends to lay brown eggs.

Some strains perform better in cages, while other strains do better in alternative housing systems. The difference originates from the breeding program. It takes several years to adapt specific characteristics from the first selection at the top end of the breeding program through to commercial hybrid, depending, of course, on the type of characteristic goals.

Nutrition must suit the chicken

The availability of raw materials for feed is one of the determining factors when choosing a strain. Cheap feed is obviously a goal, but it must suit the strain. During a breeding program with strains bred on a standard European laying feed, selection does not centre exclusively on egg production, but also, indirectly, on their effectiveness at producing good quality eggs on a merely moderate quality feed compared to the more luxurious diet of maize and soya used in the USA. These types of birds will do well for any poultry farmer, and they will possibly perform exceptionally for those who have a very high quality feed supply. But there is a risk that they could become fat which has a negative impact on egg production.

If hens are reared in a program with superior feed, there is a big chance that they will not perform so well on a lower quality ration, because their digestive systems are more stress-sensitive.

Feed related problems

This hen has a bent breastbone and a soft beak, i.e. rickets. An error in the feeding program led to this bird using up valuable calcium reserves in its bones to create eggshells. Hens need sufficient dietary calcium intake, combined with vitamin D3 to produce eggshells. You can provide calcium in various forms, e.g. marine shells (e.g. oyster grit), limestone grit, or reused eggshells from the processing industry. But you must be cautious when using eggshells, because this can lead to the hens pecking at their own eggs. There is also a risk of salmonella if this eggshell material has not been heat-treated.

Feed requirements depend on bird age

A laying hens skeleton develops from weeks 0 to 16. Its plumage develops between week 6 and 15 (including two moults). The bird should grow continuously throughout this period and demands a good starter feed (rich in protein and carbohydrates).

Starting from week 15, the reproductive system, medullary bone and the hen's fat reserves develop. This demands a change in the feed, so that there are sufficient nutrients to support the growth and the bird is ready to start producing eggs.

When the laying cycle starts, a hen needs a good quality layer starter feed to prevent her from going into negative energy balance When she is not laying yet, the feed has low calcium content. As soon as she is about to start laying, you can switch to a maintenance feed with a higher calcium content. Higher calcium content in the feed will prevent the hen from having to extract too much calcium from her bones to make her eggshells. In that way the hen can continue production without draining her special reserves of medullary bone, and she will not suffer brittle bone disease later in life.

Older hens have problems maintaining calcium levels in their bones. You should modify the feed according to eggshell quality monitoring. Supplementary grit or limestone chips might be desirable. You can restrict excessive egg size by slightly reducing the fatty acids in the feed. Do not cut down essential amino acids, because this will reduce your laying percentage.

Development

Breeding lays down the basis for good production levels, which must be maintained for increasingly longer periods nowadays. Make sure the hen has the opportunity to develop well, and has the required energy to do so. She has to deposit enough energy, calcium, and phosphorous in a good skeleton. This is very important for a good calcium reserve and supply for eggshell formation. The hen also needs sufficient energy intake to develop her reproductive organs, and enough to prevent an immediate negative energy balance when she starts to lay. Those that race ahead are quicker dead!. Hens that start laying before the foundations are laid will also stop laying much earlier.

The relationship between hen weight and egg weight

Egg weight is interconnected with the age and weight of the chicken when she reaches sexual maturity. The combination of a low hen weight and early maturity can lead to small eggs throughout the cycle. High hen weight and late maturity will result in large eggs all through the cycle. You can manage both of these factors by paying close attention to her needs during the pre-laying period , but can do nothing about them after the fact!

LOOK-THINK-ACT

What can looking at a hen's cloaca tell us?

The cloaca on the left is moist and the one on the right is dry. A moist cloaca indicates that this hen has developed sufficiently and is ready to lay.

Common mistakes during rearing, which have an effect on the eggs

Mistake during rearing	Impact during laying
Hens are too fat when they come into lay.	Bad for egg production, causes less efficient feed utilisation during laying.
Hens are too light, even though sexual maturity is under way.	The hens will suffer negative energy balance. That will have consequences affecting peak production and persistence, because these hens have no reserves to help them handle environmental stress.
Feather pecking was not prevented well during rearing, and the hens have poor plumage.	They will consume extra feed to maintain their body temperature These hens are poorly insulated and may exhibit non-desirable feather pecking behaviour. Pecking wounds are a port of entry for infections, such as *E.coli.*

Ready to lay

You can assess in two ways whether or not the hen is ready to start laying. The distance between the pelvic bones has to be two fingers, or the distance between the pelvic bones and breast bone should be more than four fingers. The space between the pelvic bones is the easiest method. You have to be able to move the pelvic bones slightly.

With the hen on the right, you cannot move the pelvic bones well and two fingers will not fit between them. This hen is not yet sexually mature enough to start to lay. The hen on the left has supple pelvic bones that you can move, and the spacing is greater than two fingers. This hen is ready to laying eggs.

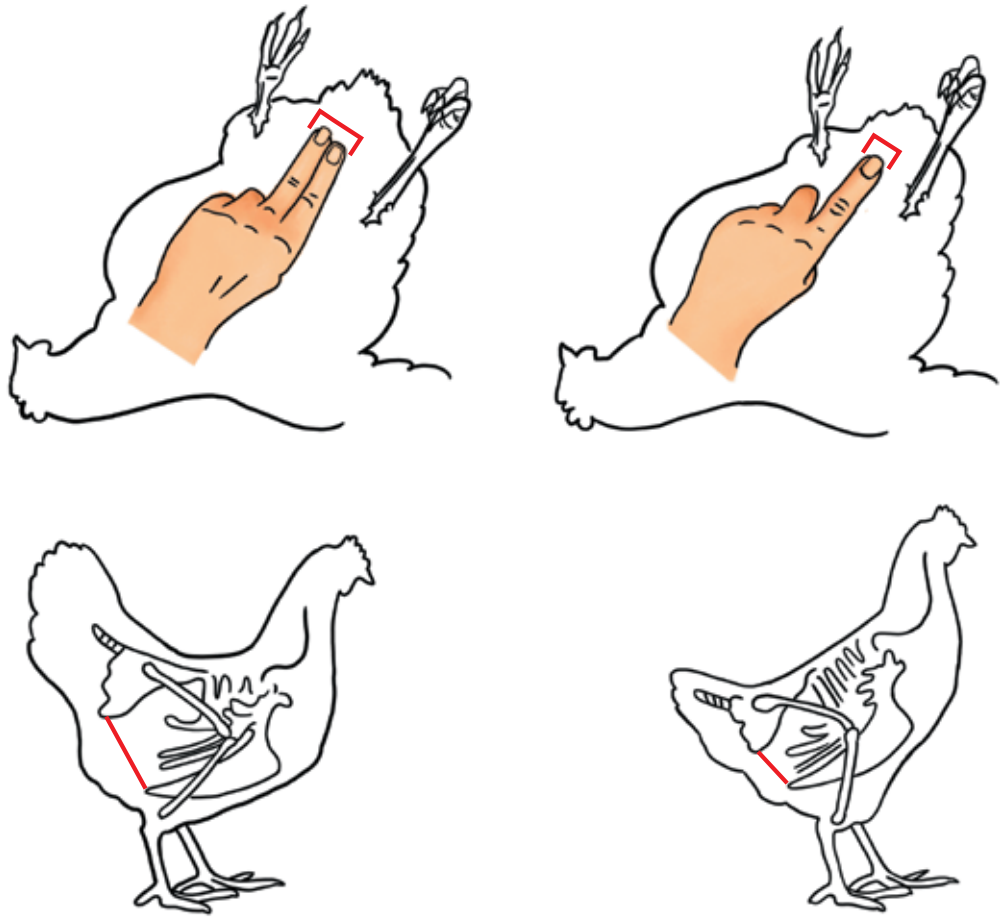


Illustration of the distance between the pelvic bones (top) and the distance between pelvic bones and breast bone (bottom).

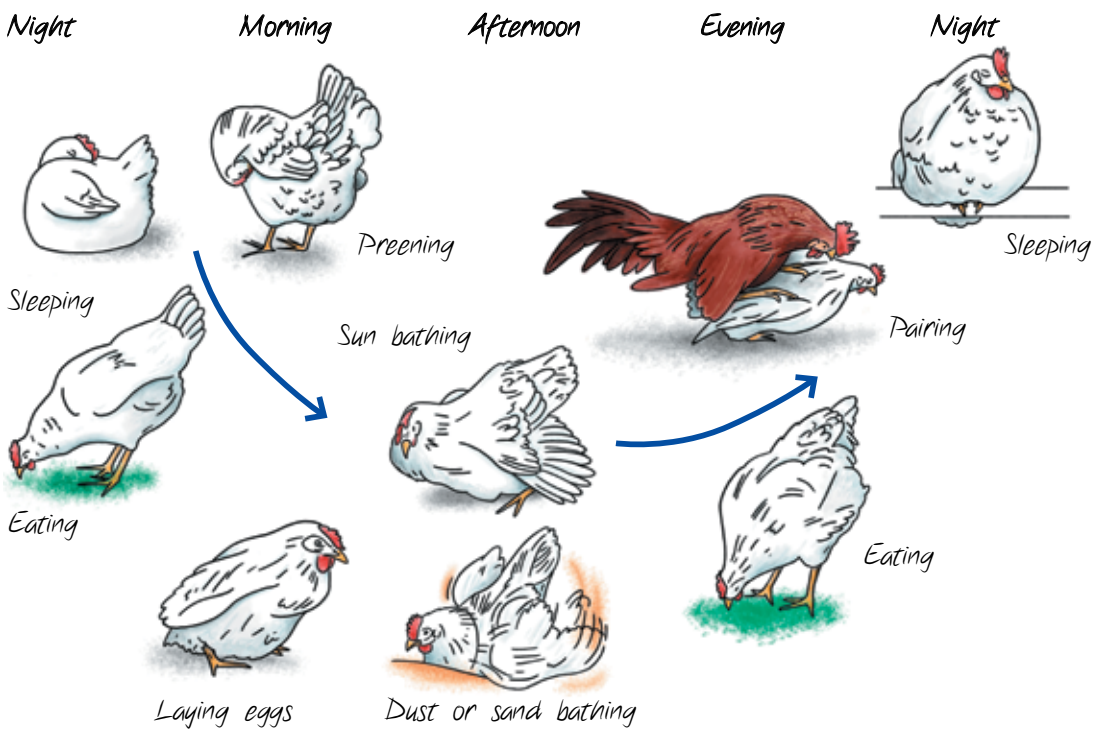
Light intensity

The fact that lighting duration has an effect on egg production is evident from observing wild birds in nature. They have a winter break, during which they do not lay, because of the short day length. Lighting in hen houses increases the day length, which results in hens continuing to lay even if it is winter outside. One funny factor is that chickens in the wild sometimes suddenly lay eggs when it snows. Snow reflects a lot of sunlight so perhaps the day appears lighter and longer to the hen.

The effect of light on the start of laying

In nature, egg laying is influenced by the day length and light intensity. By registering day length, a hen 'knows' that Spring is coming and hormone production begins. Extending the day length and increasing light intensity simulates spring, and thus stimulates sexual maturity and the onset of egg laying. The hormonal processes change when the hen sees that her clutch is complete. That is pre-programmed in the hen's brain. When the eggs are removed, however she continues laying. If you replace the eggs with fake ones, she will not lay any additional eggs. So it is clear that egg laying is influenced by a number of visible stimuli. These natural behaviours are, for the greater part, bred out of modern commercial hens. In countries around the equator there are smaller variations in daylength. The influence of daylenght on sexual maturity is also smaller in these regions. The higher ambient temperature does have a bigger influence. A higher temperature leads to earlier maturity.

Chickens have a natural daily rhythm. Chickens start each day eating and exploring their environment. Then they lay an egg. The middle of the day is the time for a dust bath. At the end of the day there is a peak in foraging and eating behaviour. You will therefore achieve the best production by ensuring minimal disruption to this daily rhythm. It is not just a question of avoiding disturbances at the time of laying.

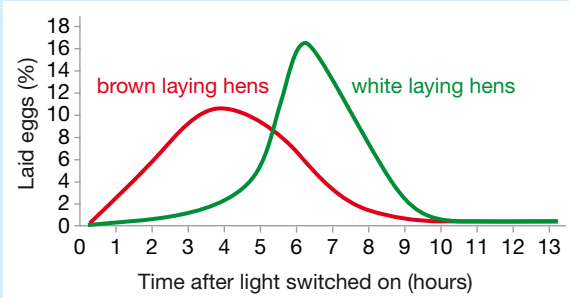


The time of laying

During the production cycle, % production (i.e. number of eggs laid per bird), egg weight, and shell quality change. The time of laying also shifts slightly. Young hens have a very consistent laying time, in the morning. But, older hens lay more often at times spread through the day and often lay later in the day. In addition, you see more variation in egg quality among the older birds. However, the variation between strains is often greater.

White hens visit the nest boxes about eight times daily, and they spend 50-65 minutes per day there. They stay in the nest box longer after they have laid an egg although this does vary with different nest systems. Brown hens go to the nest boxes about four times, and spend 25-30 minutes there each day. The fact that white hens visit nest boxes more often and spend more time per day there means that there is effectively a higher nest occupation rate. This can increase the risk of floor eggs due to lack of nest box space availability. Make sure therefore that there are enough nest boxes in relation to the strain's characteristics.

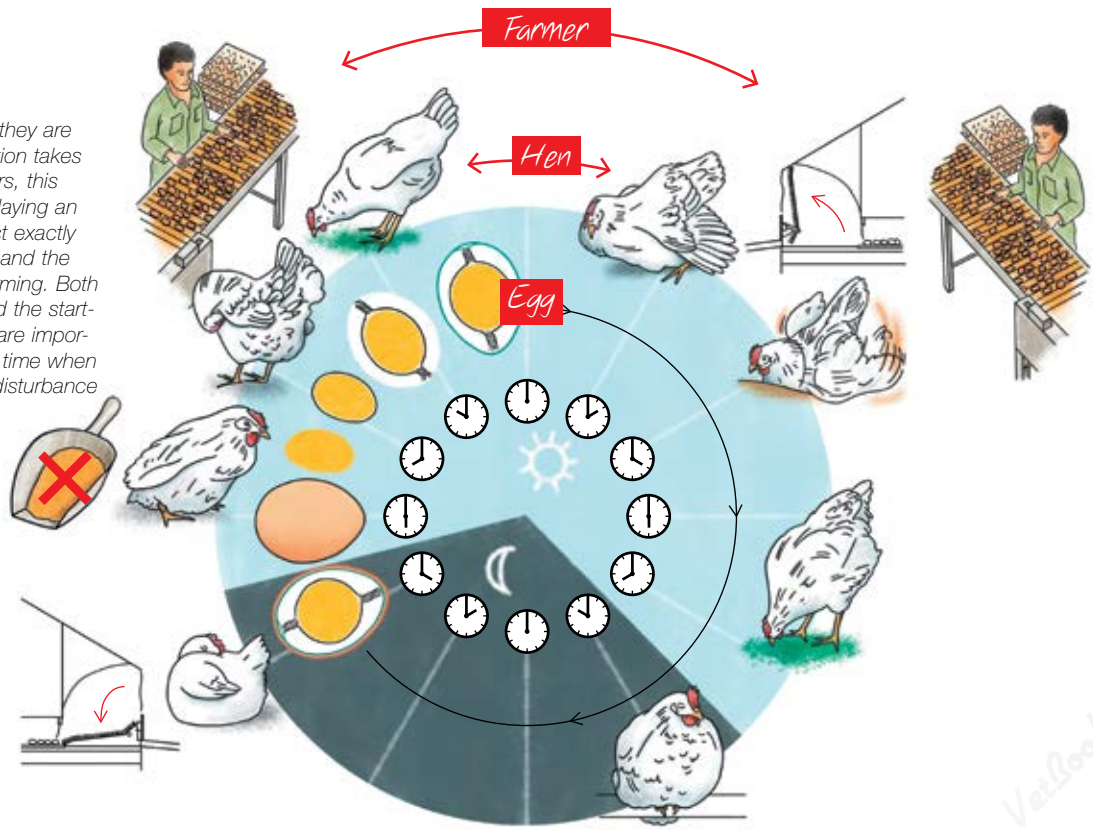
Differences in laying times



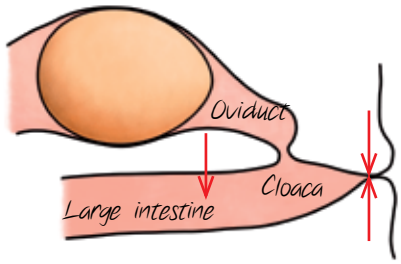
There is an observable difference between brown and white chickens. Brown hens go straight to the nest boxes when the light comes on, and they lay their eggs during the morning. The peak laying time is around four hours from the lighting switching on.

Feed times

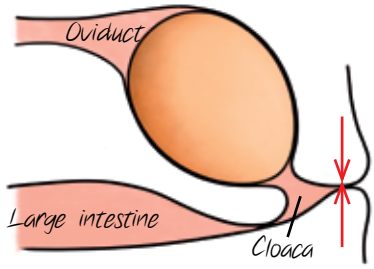
Never feed hens when they are laying eggs. Egg formation takes around twenty-four hours, this means that the time of laying an egg corresponds almost exactly with the next ovulation, and the start of the next egg forming. Both the laying of an egg and the starting a new one forming are important events, so this is a time when you want to avoid any disturbance among the hens.



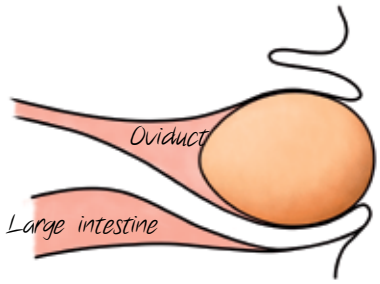
Laying a clean egg



1. *The egg comes out of the oviduct and presses the large intestine closed, a neat mechanism that prevents any manure getting onto the egg.*



2. *The cloaca itself remains closed, but the egg is pushed up. And that often causes the egg to turn around.*



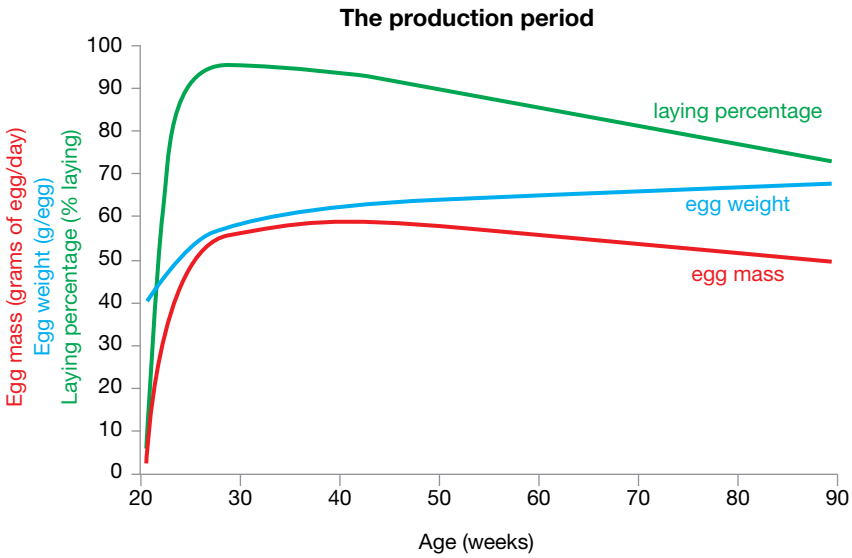
3. *The hen lays the egg clean through her slightly protruding cloaca, while the latter part of the oviduct still encloses the egg.*

Points of attention in the laying period

You can manage for future egg weight, and egg quality with good rearing, a well-planned cycle length, a fine-tuned ration, and good flock health. Egg production starts when the hen is about 20 weeks old and reaches peak egg production (98%) between weeks 28 and 30. Egg weight increases rapidly through to 60 grams at 30 weeks of age, and will continue to increase at a rate of 0.1 grams per week.

A uniform flock with sufficient bodyweight will ensure the highest chance of producing sufficiently heavy eggs at the beginning of the laying cycle and a flock like that is easier to manage.

If a flock has been reared for one extra week (18 instead of 17 weeks) they tend to have had more time to recover from vaccinations and to build up good immune resistance. They also tend to handle stress better (e.g. transport from the rearing unit to the laying house). Another option might be to wait a little longer before stimulating laying with the lighting, as this will delay the onset of lay and will increase initial egg weights.



% Egg production, egg weight and egg mass during the laying period. The egg mass is the egg weight multiplied by the % production.

First weeks in the house:
Only open up the nest boxes when the first eggs are being produced. The first eggs will be laid on the floor. It is important to collect and remove floor eggs every two hours after the light comes on.

Up to peak laying:
If the laying percentage or feed intake is not up to scratch, give the hens richer feed (fish meal, milk powder, or extra soya). Make sure the hens empty the feed troughs thoroughly once every three days. Hens' tend to eat to satisfy their energy requirements.

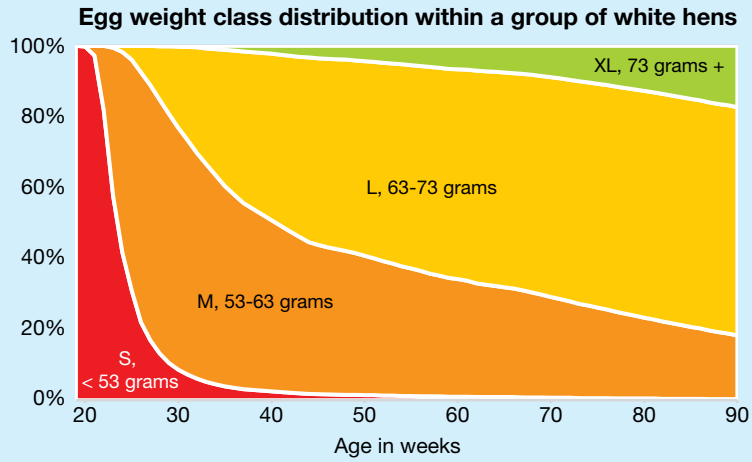
After peak laying:
As egg weights increase, shell quality drops. To minimise this, switch over to the desired feed phase in good time, and perhaps provide extra calcium (limestone particles) but less phosphate.

Managing egg weight

If the egg weight is not up to scratch, check the flock health and feed quality. If there is no question of disease playing a part, try and manage the problem by manipulating the feed. More methionine and linoleic acid in the feed will have a positive effect on egg weight. But make sure that the eggs do not become too heavy (if that starts, reduce the methionine and linoleic acid). Never apply any feed restriction measures, because this is associated with a risk of feather pecking.

A large egg is weaker

A larger and heavier egg has a thinner and weaker shell than a normal one. You can prevent your eggs from getting too large by keeping flocks for a shorter duration, or by moulting them. However, this is not permitted in some countries. Not only is the shell thickness different from normal, its composition is too. For example, there is less calcium in a large egg, and that reduces the shell quality.



Egg weight during the laying cycle

Egg weight varies through a hens laying cycle. Young hens lay smaller and lighter eggs, and they become progressively bigger and heavier as the bird ages.

Pay careful attention to the hens' weight. Weigh the hens weekly, at the same time of day, during the first ten production weeks. Automatic weighing is preferable, because it saves labour and gives you a good picture of hen weights throughout the production period.

A laggard, on the right, has a false start. The egg weight of these birds will remain relatively low throughout the production period.

Development of egg quality during the production period

Characteristic	Start of the production (20-35 wks)	End of the production (65 wks plus)
		
% production or in lay	At 21 weeks of age, about 50% of the hens are laying. Laying peak is reached at 28 weeks	Laying percentage is reduced. Depending on the feed cost and egg price, hens that have a laying percentage < 80% or poor quality eggshells are usually culled
Egg weight	60 g	65 g
Shell	Shell strength: 40 Newtons	Shell strength: 38 Newtons
Thick albumen	HU: 88	HU: 80 (thinner)
Yolk and egg size	Smaller yolks (= small eggs)	Larger yolks (= big eggs)
Leakers/spilled egg contents	0%	0.8%
Hairline cracks/other cracks	0.1%	9% with hens at 90 weeks, can even be up to 12%. An average of 4% cracks through a cycle is normal
Shell colour (with hens that lay brown eggs)	Dark	Light
Total rejects (classified as second grade)	< 3%	< 10%
Second grade, delivered separately	< 1%	< 10%
Abnormalities	Relatively many double yolkers and shell-less eggs	Relatively few double yolkers and shell-less eggs

Culling hens

There are two main reasons for culling a flock prematurely:

1. Mortality is excessive.

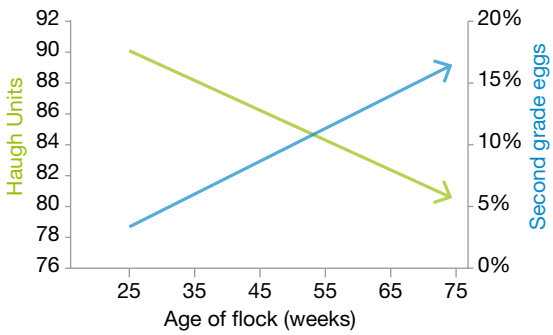
2. Egg quality becomes too poor (weak shells).

Dirt on shells is not in itself a reason for culling. You will have more second quality eggs for the processing industry, but they will still make money. Insufficient production may make a poultry farmer decide to cull birds prematurely. It depends on the egg price. However, it is not always possible to set up a new flock immediately, because it takes 18 weeks to rear laying hens. Later culling also occurs occasionally if a flock is doing very well. But it is not always possible, because the arrival of a new flock is often already on the schedule.

Production problems

Inevitably, as the laying cycle progresses, you will see changes in the eggs. In addition to that, you might see unexpected differences in the physical qualities of your eggs, caused by stress, disease, or changes in water or feed quality. Knowledge about the different signals helps you to use your management skills to handle things well.

Relation of hen's age and egg quality



This graph shows the development of the thick albumen and second grade eggs and the age of the hen. The Haugh Units decrease, although this is less of an issue than in the past due to genetic progress.

Old hens with small eggs... There is something wrong!

Normally, older hens will lay larger eggs. S class eggs in older flocks are therefore not normal. If egg weights are less than 53 grams at this stage, there is definitely something wrong. Obviously, the processing industry does not want these types of egg.

Hens that look as if they are in a daze, often with their eyes closed, are not drinking enough or not at all. What's the cause? Is the hen ill or is there something wrong with the drinking system?

Causes of egg production problems

Cause	Effect on eggshells	Effect on egg content	Loss of production %	Bird signals
Mycoplasma synoviae	Eggs with semi-translucent pointed ends	-	0	Many second grade eggs
Mycoplasma gallisepticum	Eggs with a, sugar-topped, pointed pole		0-15	Sometimes minor respiratory problems, sometimes worse because of combined infections
TRT	Pale shells	-	1-10	3-5% have congested heads/nose
Infectious Bronchitis*	Rings, sandy points, asymmetric eggs	Watery egg white, separated air chamber, broken chalazae	5-15	Reduced feed intake, airway problems, wet droppings due to kidney malfunction
Infectious Bronchitis infection suffered during rearing**	Pale and weak shells, soft-shelled eggs, sandy points, rings, asymmetric eggs.	Watery egg white, separated air chamber, broken chalazae	10-90	False laying, kidney problems, or the hen had respiratory problems during rearing
ILT	Pale shells	-	5-20	Serious breathing difficulty, mortality
Feed quality	Changeable	-	5-20	Poor feed intake
Vitamin D deficiency, Ca/P balance	Thin shells or soft-shelled eggs	-	10	Keel bone softening
Tremovirus (Avian Encephalomyelitis)	No	-	10-60	No
Egg Drop Syndrome	Pale and weak shells or shell-less eggs	Murky egg white	30-50	No
Avian Influenza, Newcastle Disease	Pale eggshells, shell-less eggs, deformed eggs	Watery egg white, separated air chamber	10-100	Breathlessness (serious), diarrhoea, nervous symptoms, high mortality

* *It is unusual for all the symptoms mentioned here to be present simultaneously in a flock.*

** *The same applies here as for IB. Moreover, the consequences in the laying period will depend on the age of the birds when the IB infection occurred during rearing.*

Specific diseases and egg quality

Some diseases have a direct effect on egg quality, this is why abnormal eggs have an important function as a signal.

Infectious Bronchitis

Sometimes, you find a strangely shaped egg or one with abnormal colour. Dented, ribbed or bubble eggshells that occur repeatedly might be caused by Infectious Bronchitis (IB). This is even more likely if egg production is reduced.
IB also causes the egg white to be watery or the chalazae to be broken.
IB occurs often and it is very infectious. The IB virus reproduces in multiple locations in the oviduct, and causes infections at each location, which in turn inhibits optimal egg formation. IB can also affect kidneys and the respiratory system. This depends on the variety of virus that causes the infection. The virus is transmitted by inhalation or swallowing. An infection can arise within 18 - 36 hours following contamination. If the animals are sick, you need to reduce the protein content in the feed, to allow the kidneys to rest. Infected animals excrete the IB virus for weeks after recovery, and it can remain living, secluded in the intestinal tract for months. When a symptomless carrier bird gets stressed, e.g. during transportation or other infections, she may start excreting the IB virus once again.
You can prevent IB by:

- vaccination
- good biosecurity
- environmental temperature control
- maintaining good air quality
- avoiding excessive stocking rates

Typical IB eggs

In the first photo you see an egg with a sandy top, i.e. locally rough shell. This occurs mainly on the blunt end of the egg. The second photo shows a ribbed eggshell. The internal shell membranes were still filled with moisture and albumen at the time the eggshell was calcified. Both of these irregularities could be caused by Infectious Bronchitis.

Watery thick albumen is one symptom of Infectious Bronchitis. Left, a good egg – Right, an egg affected by IB.

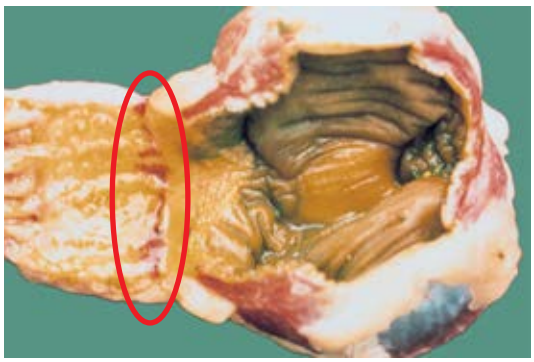
A 'False layer' cannot lay eggs because the oviduct is malformed because of an IB related infection. This hen is sitting in a typical penguin stance and should be culled.

Newcastle Disease

If you suddenly find pale eggshells and shell-less and soft-shelled eggs with watery albumen and a loose air chamber, you should suspect Newcastle Disease (ND or pseudo-fowl pest). Hens infected with ND have breathing difficulties, and have green, watery diarrhoea. They also exhibit typical nervous system symptoms such as paralysed wings and heads (torticollis = wry neck). The mortality rate is high. The period between contamination and infection is short, only four to six days. Birds pick up this disease through contact with infected wild bird populations, or through drinking or eating from a source that an infected wild bird has used previously. ND is a notifiable disease in many countries.

A deformed, pointed egg is also a signal of ND.

A twisted neck might be a signal of an ND infection.



One symptom of ND is the occurrence of haemorrhage in the glandular stomach (proventriculus). Mainly visible at the transition between glandular stomach and muscular stomach.

Pale eggshells can be a signal of ND. ND is caused by a virus. Vaccinating poultry against this disease is obligatory in many countries. The prevention policy comprises vaccination and good biosecurity. Maintain good hygiene and never exchange any materials with other poultry farmers. Preferably, prevent any contact at all between the chickens and wild birds. There is no treatment.

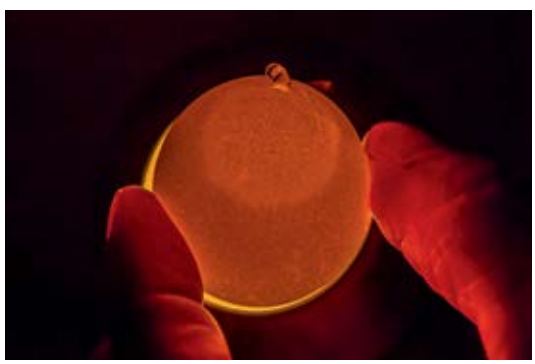
Mycoplasma

If you see eggs with a rough and thin point, and with clear demarcation between that and the normal part of the shell, they are probably what is known as 'Glass top eggs'. The number of these abnormal eggs can amount to 25% of a flock's eggs. These second grade eggs earn less and often break during the process. The reason is due to damage to the reproductive system caused by Mycoplasma bacteria (*Mycoplasma synoviae*). The problems with glass top eggshells usually occur when a flock is around 28 to 35 weeks old. The animals often do not look sick.

The damage to farm business is mainly the extra time spent sorting out these eggs, and cleaning soiled eggs. They are also a nuisance for the packing station. Not all sorting machines are capable of picking out these 'glass top eggs'. They can break and empty their contents in the machine, which in turn can lead to operational hold ups and the machine becoming contaminated.

Once a laying hen starts to lay 'glass point eggs', she will do so for the rest of her life, because the oviduct is permanently damaged. Thus, treatment is never conclusive, the infection remains in the flock. This makes a multiple age system in a house a risk factor, because there will be a continuous cycle of the older, infected birds infecting the younger birds. You can determine cases of Mycoplasma with a blood test. Mycoplasma is also susceptible to disinfectants and dehydration. They do not survive long in a clean and dry house. However, they can shelter and survive in egg remains and other materials for days and even weeks. *Mycoplasma gallisepticum* is another mycoplasma bacteria that occurs less often with laying hens. Vaccination for *Mycoplasma gallisepticum* is possible. Within the EU, *Mycoplasma gallisepticum* is a notifiable disease.

A 'glass point egg', caused by Mycoplasma.



'Glass point' eggs in front of a candling lamp. The lighter point is clearly visible.

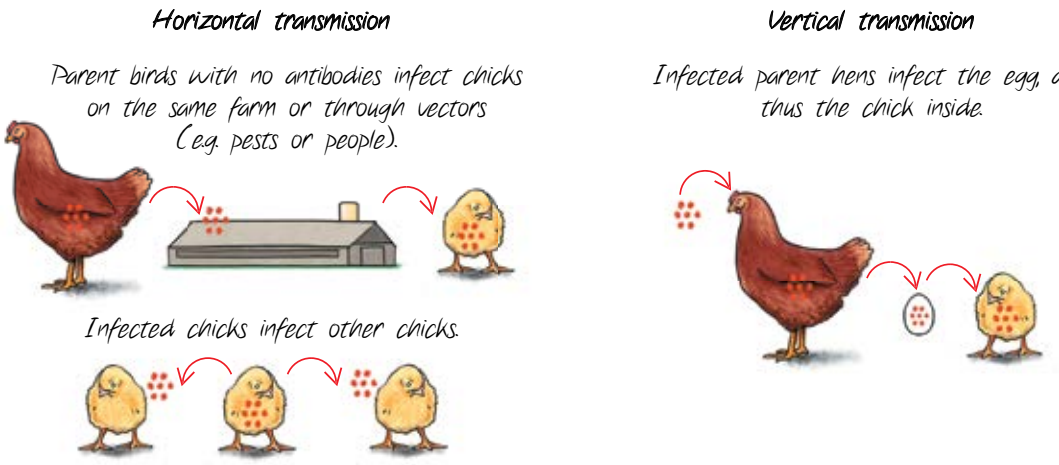
Symptoms on the animal, with a very serious infection include secretions from the nose and eyes, coughing, and infection in the air sacs.

Egg Drop Syndrome (EDS)

Are you finding misshaped, pale eggs, with weak or soft shells, or shell-less eggs? Do those eggs have murky albumen? If so, it could be a signal that the flock has an Egg Drop Syndrome (EDS) infection. There will also be an associated decrease in production (30 to 50%). The hens themselves will have diarrhoea. EDS does occur occasionally, especially during the initial months of production in flocks of the heavier strains (brown laying hens, broiler parent hens).

Prevention

- Only use clean, disinfected egg trays.
- Keep the hens segregated from waterfowl, e.g. ducks and geese.
- If the drinking water is infected, disinfect it.
- Vaccinate.



EDS is caused by a virus. The disease spreads slowly, but faster in free range or aviary houses than in colony cage systems. Infection arises through contact with domestic ducks or geese, or through wild bird droppings in the drinking water. Hens can pick up the virus from parent birds that are carriers without symptoms, or from infected birds kept in close proximity.

Egg Drop Syndrome symptoms


Misshaped eggs

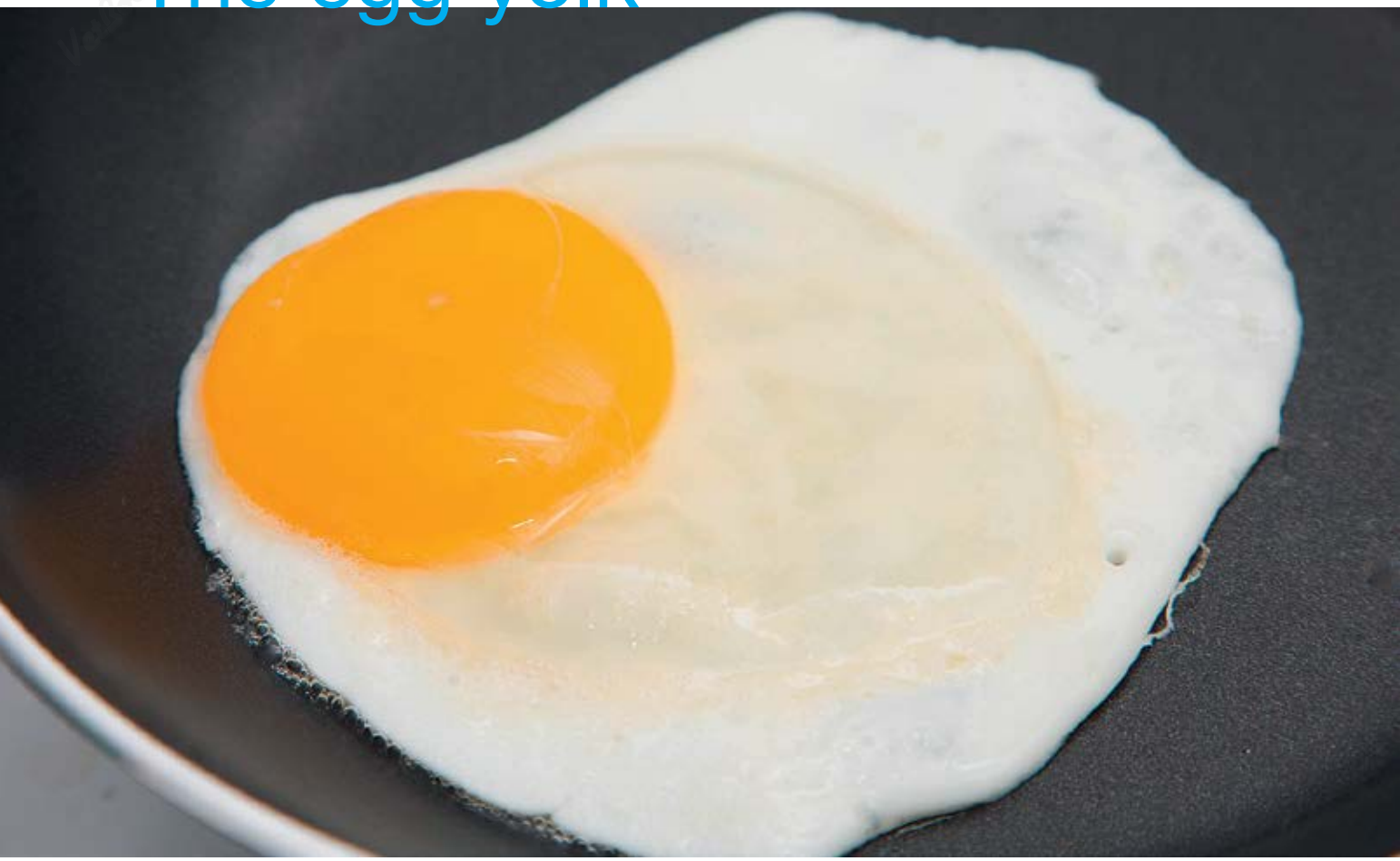

Pale eggs


Weak shelled eggs


Watery diarrhoea

CHAPTER 4:

The egg yolk

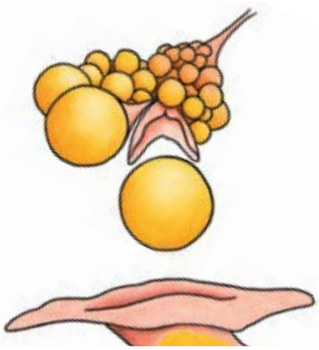


The egg yolk reflects the hen's health. From a consumer point of view, it is the healthiest part of the egg. It is full of vitamins, antioxidants, and polyunsaturated fatty acids. As a poultry farmer you should crack an egg regularly, to gain insight into the nutritional and health status of your hens.

You can read a lot of information about the hen's health and its nutritional status from looking at the egg yolk.

A mature egg cell (the egg yolk) can reach a diameter of about four centimetres in about seven days. It is one of the few cells that we can see with the naked eye. The germinal disc is on the yolk. In a fertilised egg, the germinal disc develops into a chick, and the yolk mass serves as nutrition for the developing embryo. The yolk floats a bit above the middle in a fresh egg, the germinal disc close to the heat of the mother hen. The brooding hen turns the egg every now and then to keep the yolk from sticking to the shell membranes. When boiling a fresh egg, the albumen hardens around the yolk and the yolk is pushed back to the middle.

The yolk weighs about one third of the egg's total weight. In white eggs the amount of yolk is a bit higher than in brown eggs.



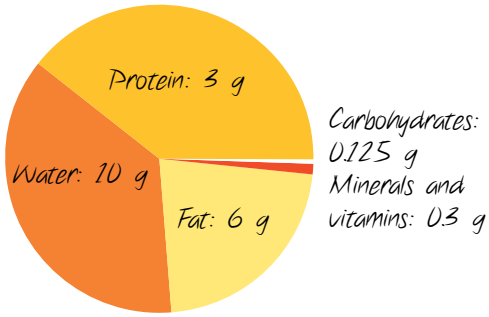
The yolk forms or matures in the ovary. When a mature yolk is released from the ovary it is received into the infundibulum (funnel opening of the oviduct). After release from the ovary the composition of the yolk remains the same.

Yolk characteristics

The egg yolk reflects the hen's health. The poultry farmer needs to check broken eggs extra carefully too, because there is always a possible connection between cracks and the internal egg quality.
The pH of the yolk in a fresh egg is around 6.0. In storage the pH rises to 6.4-6.9. The raised pH causes small abrasions to occur in the vitelline membrane which surrounds the yolk. This leads to the yolk getting mixed with the albumen.

Larger yolk = bigger egg

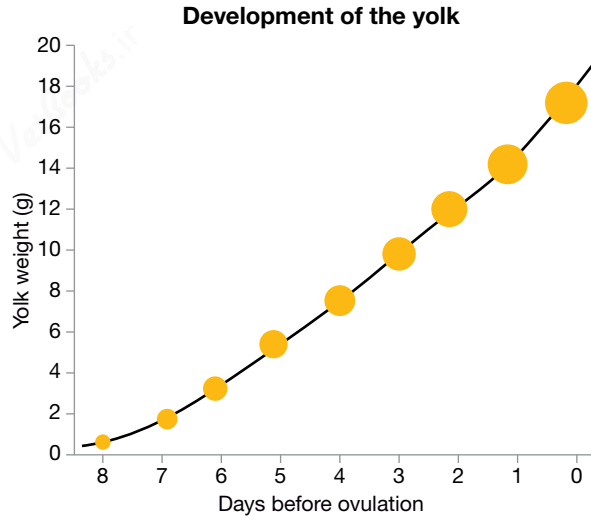
If you are feeding a high energy ration, you will get bigger yolks in your eggs, and bigger yolk automatically means a larger egg which can be sold at a premium. But it can have a negative influence on shell strength at the end of the laying period.
Egg weight depends greatly on hen weight, and the age at the time of 50% laying. The heavier the hen and higher the hens' age at 50% lay, the greater the average egg weight through the entire laying period.



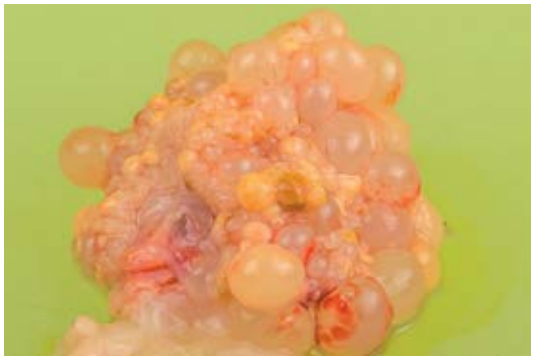
Yolk composition.

Beans and peas increase egg weights

Working beans and peas into the feed produces slightly larger eggs. Beans and peas contain a lot of linoleic acid and lysine, which has a positive effect on egg weight. The effect is not great but it may put the egg into another weight class, which is beneficial from a payment point of view.
You can also manage egg weight by only modifying the linoleic acid content. For example, if you feed thirty-five grams of linoleic acid instead of fifteen, you raise the egg weight by 0.5 g and the proportions of yolk and albumen remain the same.



Source: C.A. Kan, 2003



A young hen has all germ cells already present in the ovary.

As a hen matures, the egg cells develop one by one. So inside the hen you are able to see the yolks in various stages of development.

Useful characteristics

An egg yolk has characteristics that make it valuable for many practical applications. Yolks are used in the kitchen, in the processing industry, in artisan art work and in health care. In other words, besides their regular use as a foodstuff, yolks are used as:

- an emulsifier in foodstuffs
- a shampoo additive
- a binder in paint
- a blood pressure reducer
- a gluten binder

Blood pressure reducer

The fatty substances in the yolk include phospholipids and cholesterol. Phospholipids reduce blood pressure in humans, and reduce the risk of developing heart and circulatory diseases.

Mayonnaise

Egg yolks are often used as an emulsifier for mixing substances that do not mix well, e.g. oil and water. Mayonnaise is one good example.

Creamy ice cream

Egg yolks are mixed with sugar syrup, warm cream, and milk to make creamy ice cream. Egg yolks work as an emulsifier to bind water in substances (e.g. milk or cream). Without an emulsifier, the water would freeze into crystals, and your ice cream would not be creamy..

Shampoo

An egg yolk has a pH of about 6.0, and that is very similar to the pH of hair. The lecithin in yolks provides both a caring and cleaning effect. The emulsifying effect gathers up oil and dirt coating the hair with the water, which makes it easy to rinse off. The relatively high sulphur content in egg yolk helps combat dandruff and dry scalps.

Tempera

From as far back as the middle ages, egg yolk has been used to make paint, known as 'tempera' (mixture). Icons are still being painted with tempera. As the tempera dries, the yolk proteins denature and become water insoluble. The fat from the yolk keeps the paint layer supple. Paintings created with tempera have survived for centuries.

Yolk proteins and gluten intolerance

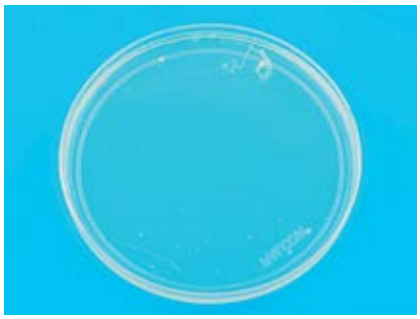
Researcher Hoon Sunwoo (University of Alberta) has discovered that egg yolk binds gluten in the stomach, which prevents it causing any damage in the intestines. The 'egg pill' could be a medicine for gluten intolerance (coeliac disease), although it is still to be fully tested but if it works it could be available by 2018.

An egg without a yolk

A dwarf egg (in some countries called a 'cock' egg) is an egg without a yolk or with a tiny yolk. This type of egg is often the last one laid in a cycle. It is also a lot smaller than a normal egg. It can also occur with young hens just starting to lay. A dwarf egg forms when for example a piece of tissue or a blood clot breaks loose from the oviduct wall. This stimulates the normal processes to create albumen and shell around it, creating a small egg. The yolk could also break in the oviduct. The yolk material will be taken up by the body, but the yolk membranes remain and form the new core around which the albumen is formed.

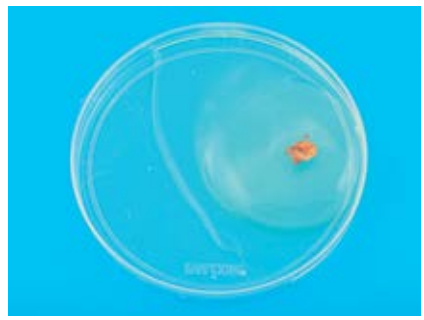
Often, dwarf eggs show concentrated areas of pigment on the shell and the entire egg is darker in colour.

They are a lot smaller than normal ones, usually around 20% of a normal egg size. The egg below is a truly large egg (double yolker).

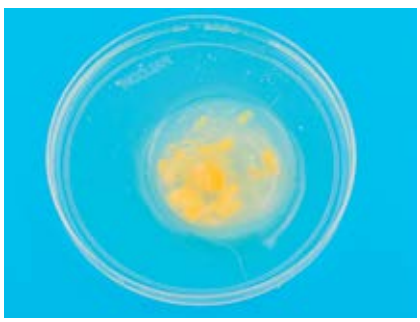


Sometimes there is virtually nothing inside a dwarf egg.

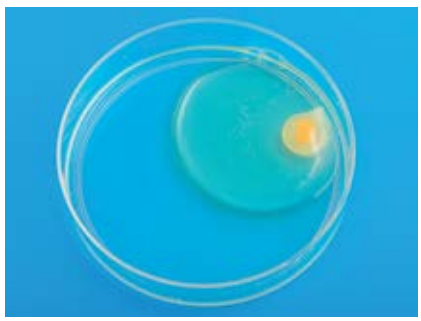
A tiny piece of tissue can form the core of a dwarf egg.



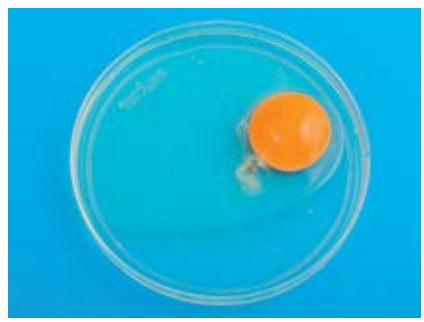
A meat spot forming the core of a dwarf egg.



A dwarf egg with some yolk material.



In the case of somewhat larger eggs (more than 30 grams), there is often a yolk formed, but it is tiny. That is clear evidence of how the yolk's dimensions affect the size of the egg.



It is a nice yolk, but tiny. Its diameter is only about 2 centimetres, while it would be approximately 3.5-4 in a normal egg.

Managing yolk quality

Besides evaluating bird health and nutrition, you can directly influence yolk quality through the feed.

There is a relationship between the quantity of fat in the laying hen feed and yolk size. If you reduce the fat percentage in the feed, you will see the effect reflected in lower dry matter content in the egg, because the yolk will be smaller. Smaller eggs (S) have a smaller yolk, not only in terms of absolute weight but also in proportion to the entire egg. You could get larger yolks by feeding unsaturated fatty acids (especially linoleic acid).

A lighter coloured yolk, when you would expect it to be a darker one, can be a signal of disrupted digestion (e.g. through disease) or something wrong with the feed.

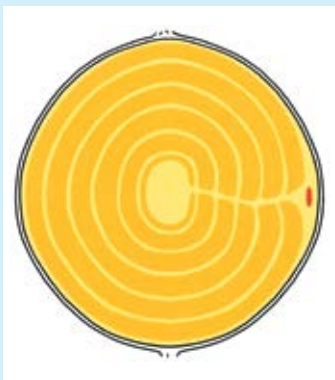
Flecked yolks

Flecked yolks with transparent to orangey brown flecks are caused by weakened yolk membrane (Vitelline membrane), which allows the egg white to penetrate the yolk. Yolk membranes become weaker in older eggs, and through use of coccidiostats. Use of those substances during laying is not allowed in the EU. Young hens lay eggs with flecked yolks more frequently. And that effect reduces after two or three months in lay. If a hen only eats once or twice per day instead of continually, you can discern clear pigment layers in the yolk.

If there is a difference in yolk colour from hens in the same flock, it may be the result of selective eating or a disease. In either case, it is a signal that you need to take action.

The presence of an a coccidiostat in the feed makes the yolk membrane permeable. Which can allow albumen to seep into the yolk, and you will see evidence in the form of pale spots in the yolk.

Yolk rings



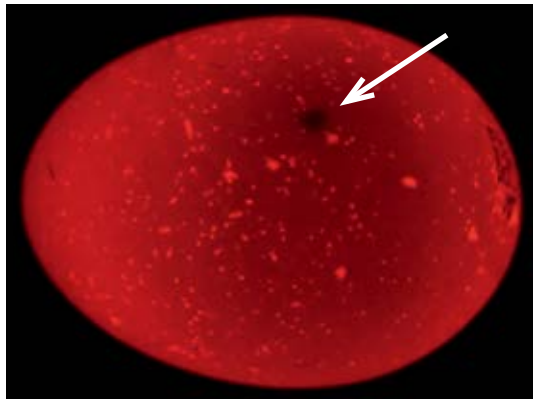
Yolk are made up of a number of rings or layers, like the growth rings in trees. Sometimes you see alternating light and dark layers in a yolk. This occurs mainly with hens that range outdoors, and when their ration is not constant. With a dark appearing yolk it might be only the colour of the outer layer. If you slice through a boiled yolk, you will see whether something was lacking in the hen's feed at any time point during the 7 or so days it takes to fully form in the ovary.

The fact that higher pH damages the yolk membrane makes egg freshness very important for splitting the egg contents in food preparation.

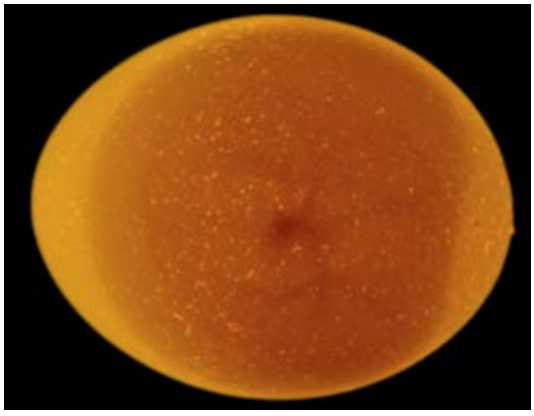
Fertilised egg or meat spot?

If cockerels mix with the hens, eggs can become fertilised. Cockerels are sometimes kept with hens in backyard poultry flocks but they can also end up among hens in other systems through sexing errors in the hatchery. Sometimes, if an egg is fertilised, the germinal disc will begin to develop when the environmental temperature is high enough (21-24°C). If an egg is fertile and has begun to develop you will see blood vessels in the yolk within as little as twenty-four hours. This is why it is so important to maintain the right temperature in the egg storage area.

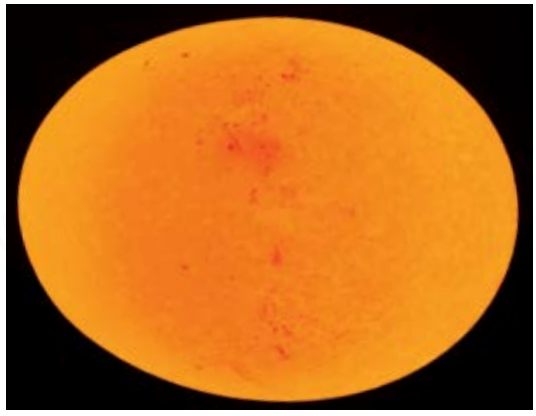
Sometimes meat spots can occur on the yolks. These are tiny bits of the oviduct that have sloughed off. Consumers often confuse meat spots with fertilised eggs, but there are very clear differences. Sometimes people even mistake the chalazae for an embryo.



The dark spot in the centre of this egg is an embryo in its early stage. This is a fertilised egg.

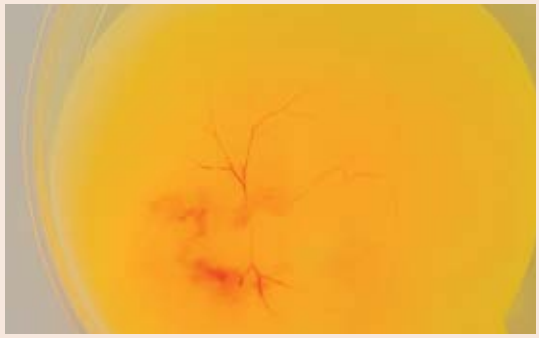


This embryo has developed relatively far already. Approx. 1 week of age.



The embryo develops, and more blood spots occur. This fertilised egg has been kept in a warm environment for a couple of days.

Difference between embryo and meat spot

Embryo	Meat spot
	
Visible blood vessels	No visible blood spots
Long and thin with a 'fat head'	Round and wide
Pink coloured	Pale (meat) or very dark red/brown (blood)

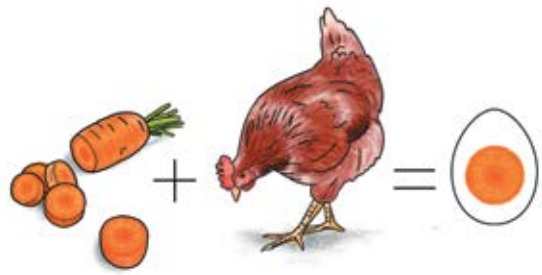
Yolk colour and customer preference

Customers have a preference for certain yolk colours. The yolk colour is determined by the presence of fat soluble, yellow to red pigments, the carotenoids which originate from the feed. You can manage colour through your choice of raw materials or enhance it with special additives. Adding natural raw materials to the layer feed, such as yellow maize, lucerne, dried vegetables, or other plant materials, e.g. grass meal, will give a darker yolk colour. Feeding most other grains will actually make the yolk lighter.

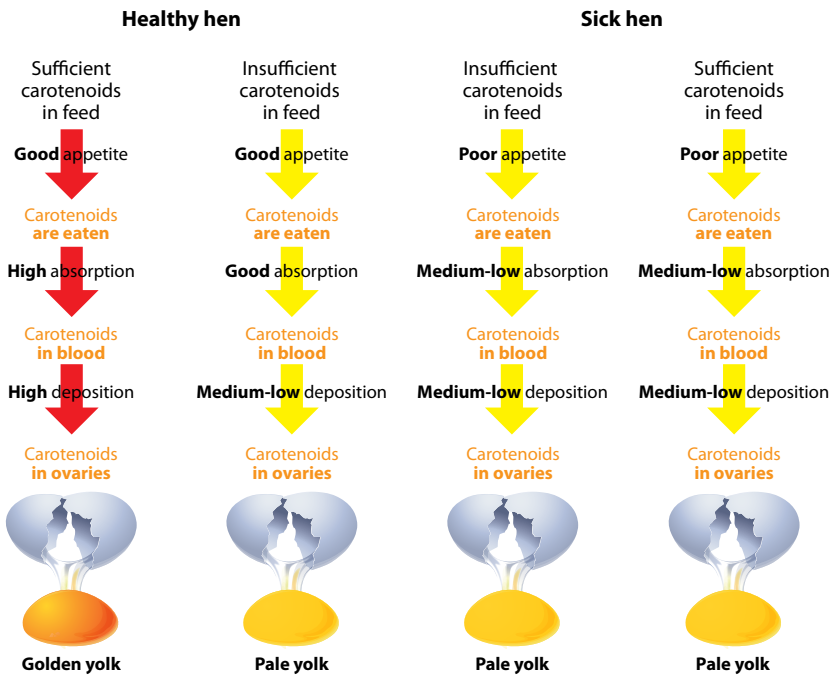
Additives for yolk colour

A golden yolk is determined by two colour components, a yellow base colour and red to deepen it. Lutein and zeaxanthin are the carotenoids that provide yellow colouring. Canthaxanthin is one of the carotenoids that give yolk a deepening red tint. You can calculate the amount of each carotenoid you should add to the feed to get the desired colour by using the advised added quantities of yellow and red carotenoids for each yolk colour.

Lucerne is fed in organic husbandry, and it makes yolks darker. Natural carotenoids also occur in the petals (corolla) of certain flowers, shellfish, fish (salmon and trout), and feathers of certain birds (flamingos or canaries), algae, and moulds.



Colours that can be dissolved in fat will show up again, especially in the yolk. That is why colourings such as carotenoids, which also give carrots their colour, show up in the yolk.



Source: DSM

Carotenoids must be taken up in sufficient amounts and be well absorbed (healthy gastrointestinal tract),they shouldn't be applied as antioxidants (low infection pressure), and must not be used as a vitamin substitute (the bird's vitamin requirement must be provided in the feed). Adding carotenoids will not have any effect if the hen is ill.

The yolk colour fan

You can determine the yolk colour using an objective colour fan (DSM YolkFanTM) This fan replaces the Roche colour fan, which has been used in the industry since 1957. The DSM colour fan has sixteen colours. Until 2016, there were only fifteen colours, but the Asian preference for a darker colour required addition of another colour to the fan. Consumers consider it to be important that yolk colour is always the same. This makes it essential to maintain consistent feed composition. In consideration of the fact that occasionally a certain percentage of egg yolks can be slightly lighter, it is good to target the colouring content in the feed composition toward one shade darker than desired.

Using the colour fan

To assess yolk colour well, you need to pay attention to the following:

- Ensure that you have a white, non-reflecting background.
- Use indirect sunlight, without any artificial light. Avoid reflections.
- Hold the swatch directly above the yolk, and look straight down at it.
- Make sure the numbers are on the bottom of the swatches so they cannot influence your assessment.
- Hold the yolk between the two most corresponding swatches.
- Always store the swatches in a dark environment, to avoid discolouration.

Holding the yolk between two colours on the fan allows you to properly assess which one is the closest.

The DSM scale goes from No. 1 (light yellow) up to 16 (dark orange). The desired yolk colour varies by country, but most prefer a value above 12. There are some exceptions. For example, in Europe: 9-13, America: 5-8, and Canada 3-5.

The colours of the yolk fan. This is just an indication. For a proper assessment you should use a real yolk fan.

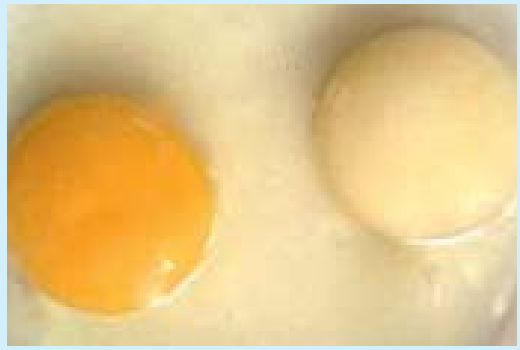
When do pigments not work well?

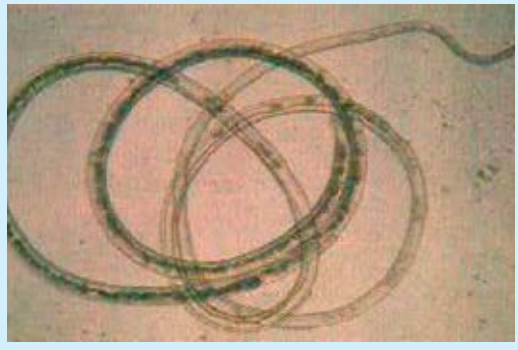
Signal	Cause and Action
Pigment breakdown in feed	Store additive and premixes in airtight containers, in a cool place, and never in sunlight. Do not store them too long.
Insufficient carotenoids in the feed	The amount of carotenoids might be insufficient. That can certainly be the case if you are using natural sources (e.g. lucerne and maize) in which concentrations can vary. Added pigments are easier to manage
Insufficient pigment reserve	Flocks that start coming into lay can have insufficient pigment reserves. Begin feeding pigment two to three weeks before the flock starts laying.
Oxidising substances or pigment antagonists in the feed	Some substances may negate the effect of pigments, e.g. barley and triticale in the feed. In such cases, you have to add higher concentrates of pigment in the feed. If oxidants are the culprit, add antioxidants.
Poor feed mixing	Always make a premix of the pigments before finally mixing them into the feed, that method produces better mixing results.
Poor storage conditions	Keep feed cool and dry. Storing feed in damp and/or warm conditions reduces the effectiveness of pigments.
Rough feed handling or transport	Handle feed carefully, to ensure that the different components do not separate. Take special care to check this if you use augers in your feed system.

Yolk abnormalities

Green yolk
Cause: this can occur with feed containing cotton seed oil, or if hens eat the plant Shepherd's purse *(Capsella bursa-pastoris).*

Platinum yolk
Cause: hairworm *(Capillaria obsignata).*





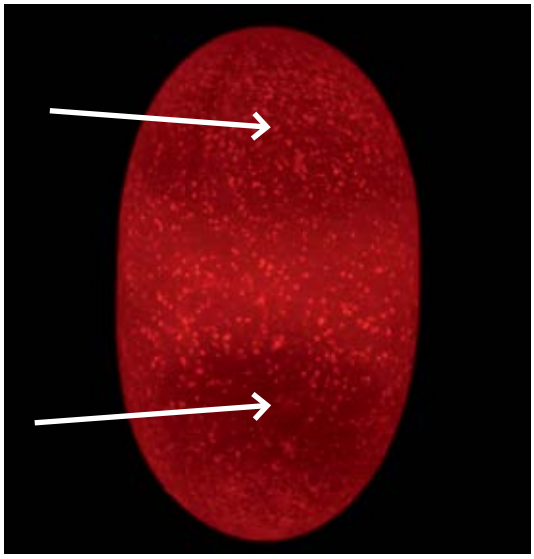
Double yolkers

Even though double yolkers are a natural abnormality, many consumers think that they are the result of human manipulation. Double yolkers are created during ovulation when not one but two yolks are released from the ovary into the oviduct at once. This occurs most often among young hens, because of ovulations following each other too closely. The second yolk accompanies the first yolk as it travels down the oviduct, which results in both being enclosed in one egg. Multiple ovulations causes irregular laying among those hens. Some consumers have a preference for double yolkers, e.g. buyers for Chinese restaurants. Chinese dishes require more yolk than egg white. Double yolkers have just the right proportion all in one egg.

If there is no special market for double yolkers, they are graded to the XL packs. This is why you might find the occasional double yolker if you buy XL eggs.

Light has an influence on the incidence of double yolkers

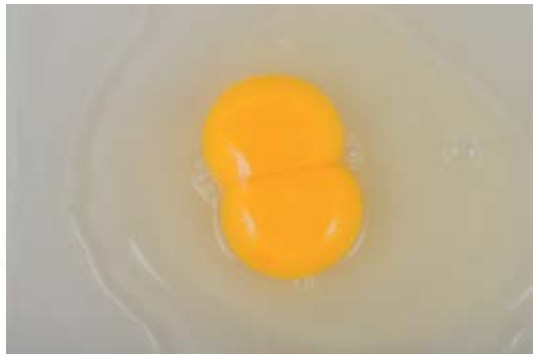
You can influence the number of double yolkers produced with light. The number of double yolked eggs can be increased due to a fast increase in light duration in the transition from rearing (8 hours light) to laying house (14 hours).



A double yolker under a candling lamp. There are two visible dark spots each representing a yolk. One is below and one above. Those are the yolks.

Egg with six yolks in one pan

You might be pretty surprised if you see an egg with a large number of yolks in a frying pan. In the photo, you can see an example, an egg with six yolks! You see the most double yolkers when hens are between 22 and 35-weeks of age.



A broken out double yolker. The yolks often lie close to each other, and that is why they do not each have their own thick albumen layer.

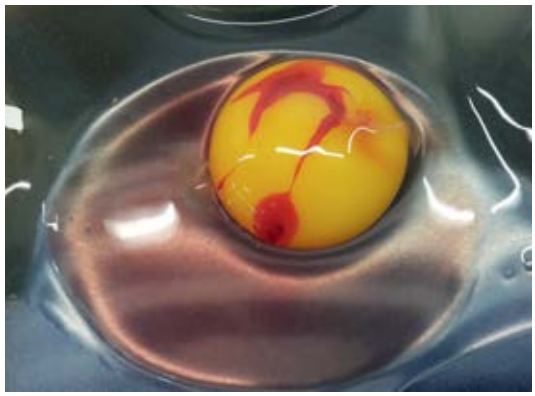
Even when the yolks are boiled, you can even see how close they are to each other.

Blood in the eggs

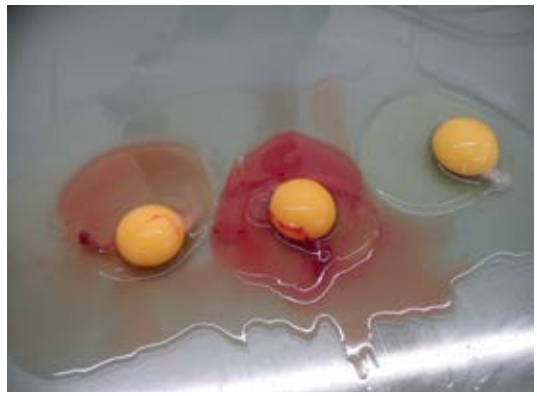
Eggs with blood in them occur more often with brown hens than white ones. There are notable genetic differences among breeds. Sorting machines can detect eggs with blood content and select them out, to avoid delivery to consumers. Broken blood vessels in the ovary or oviduct cause blood in eggs. If the problem occurred in the ovary, all the blood will be in the yolk. If it occurred at a later stage, you see it in the egg white.

The following factors can cause burst blood vessels:

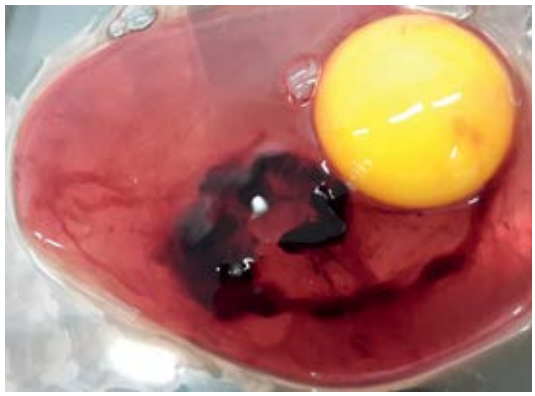
- Insufficient vitamins A and K in the feed – It is also very important that the vitamins are properly mixed through the feed
- An excessive amount of lucerne meal in the feed – It contains a substance that blocks vitamin A uptake
- Mould in the feed
- A continuous light program, or one with too many short periods of light and dark – Sufficient rest at night is important for hens
- Sudden occurrences of stress in the house – Panic movements can result in burst blood vessels.
- Avian Encephalomyelitis (AE or epidemic tremor) – Make sure you have an effective vaccination program



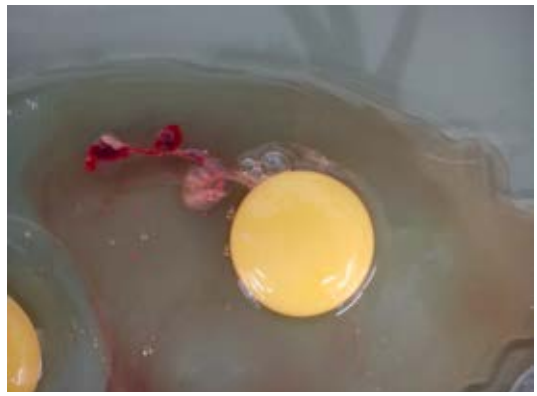
A burst blood vessel close to the ovary.



Three eggs from the same hen – Right, normal – Left, an egg with some blood – Centre, one with a lot of blood. Thus, this is a repetitive haemorrhage or one that has continued for a couple of days.



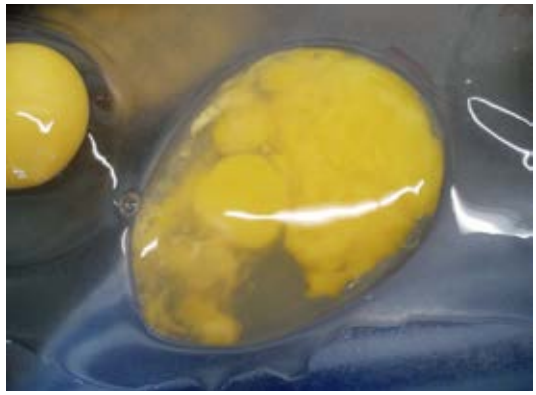
Blood in the albumen and chalazae – This egg also has very little thick compared to thin albumen.



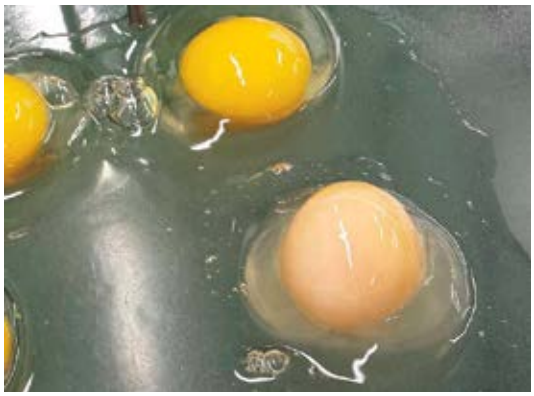
A large blood clot resulting from a burst blood vessel in the oviduct at the time of egg formation.

Other yolk abnormalities

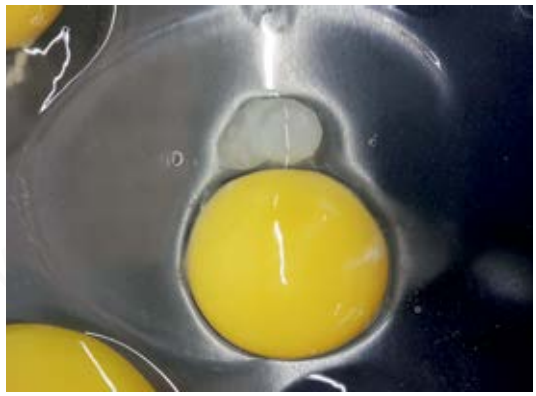
Yolk deposition in the chalaza.



Yolk material spread through the albumen – The yolk is broken during albumen deposit.



Extremely light yolk (and opaque albumen) – This is possibly the result of a fault in the feed (insufficient carotene). If all the yolks are coming from the same flock, the problem must originate from the individual hens.



Lump of thick white around the chalazae.

Chalazae with yolk flecks.

Yolk material deposits in the chalazae.

Salmonella infection in the yolk

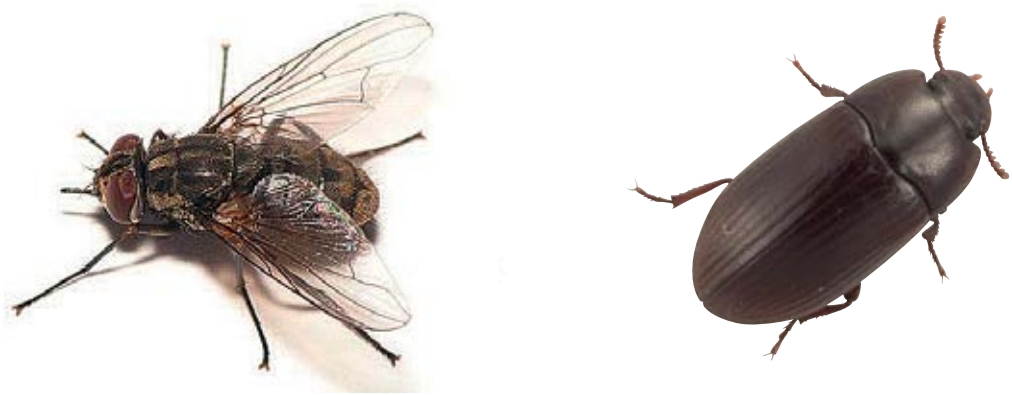
Normally speaking, only a small percentage of birds in a flock will become infected with salmonella. The infection usually occurs in the birds intestines (caeca) and salmonella is shed in the droppings.

Eggshell infections occur mostly during laying, through infected droppings in or around the cloaca. In the nest boxes, other eggs can pick up an infection by sucking bacteria in when cooling. Make sure nest materials are clean.

In addition, there is a risk of the air chamber expanding after laying, and air is always a negative factor, which can increase the rate of decay.

External egg infections rarely reach the yolk. There is a sort of natural antibiotic in eggs, which protects the chick from pathogens.

Yet, bacteria can sometimes still get into the egg and infect the yolk. That occurs when the yolk gets too close to the shell membrane, giving bacteria the opportunity to get inside, which can occur when eggs are older. The high fat content makes the yolk drift inside the egg. *Salmonella Enteritidis* (SE) can also get into the yolk as it forms through the hen's bloodstream. This however is very rare as most laying hens are usually vaccinated against salmonella.



A salmonella infection can get into the house through pests, such as flies or darkling beetles (Alphitobius diaperinus).

Vaccination against salmonella is administered during rearing, with a vaccine added to drinking water. Adding a colour marker to the solution allows you to see if the chicks have all taken a dose (left). You can even see it in the crop by looking through the skin (right).

Infection through the bloodstream

Once a hen has picked up *Salmonella Enteritidis* (SE) through infected material (dust, droppings, feed), it can penetrate the intestinal wall and spread further, into the body and the bloodstream. It can then infect internal organs such as the ovary with its yolks, which will result in bacteria being in them when the egg is laid. Salmonella already present in the egg can also cause rotting. However this process usually only begins, at the earliest, six weeks after laying, under normal storage conditions (18°C). However it will happen much more rapidly at temperatures above 30°C. One in 10,000 egg yolks can be infected with salmonella. Treatment for a salmonella infection is not allowed in the EU.

Combating and preventing salmonella infections

Salmonella bacteria can get into the poultry house through many routes, but the most important infection sources are:

1. Pests (especially mice, but other examples include, cats, dogs, and darkling beetles)
2. Feed and dirty working materials, such as tools, egg trays, crate, containers, etc.
3. People (manure or dust on clothes, under shoes, in the hair, etc.)

Vaccination can reduce effectively the number of SE positive flocks.

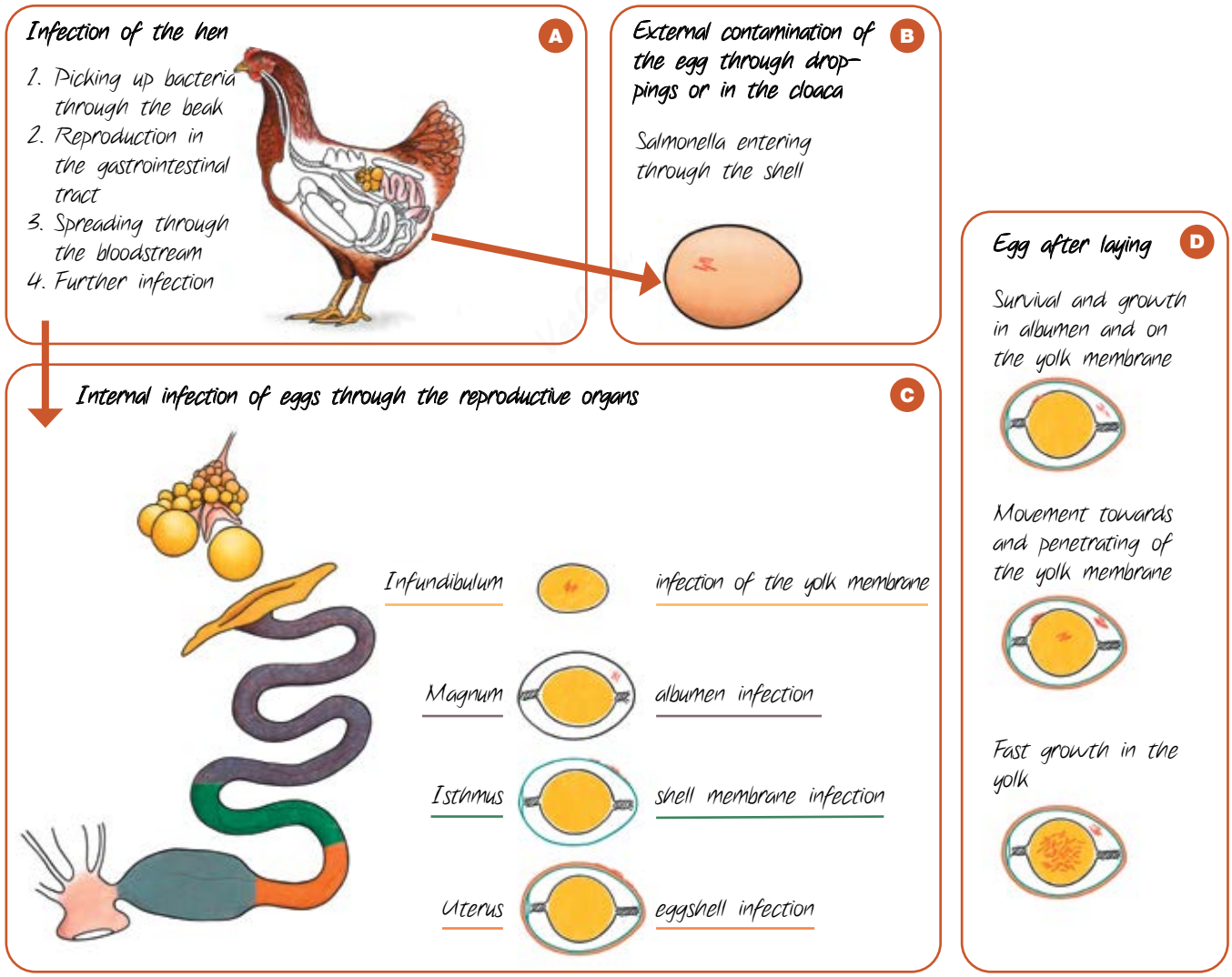


Illustration after: Inne Gantois et al. 2008

An infected hen can infect an egg in various ways. Shell contamination can come from manure or the vagina. Internal egg infections come through the bloodstream. The location of the bacteria depends on the position in the oviduct where the infection occurred. These bacteria can survive in the antibacterial environment of the albumen, migrate towards the yolk membrane (vitelline membrane), and penetrate it. Once they reach that nutrient-rich environment, they can reproduce in great numbers.

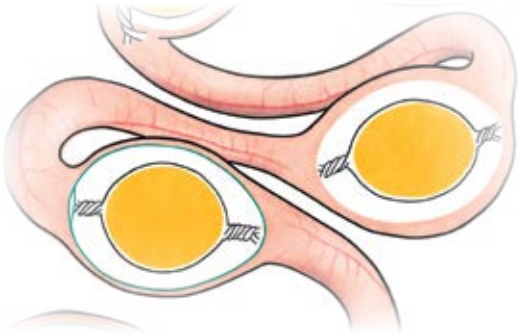
CHAPTER 5:

The egg white

The yolk and albumen are perfectly isolated from each other by the yolk membrane. That is why you can separate them.

The egg white or albumen has multiple functions in an egg. It provides nutrition and insulation for the chick, acts as a shock absorber, and it has a protective function against bacteria. In addition, it serves as a supporting structure for the shell membranes with the eggshell during the egg formation process.

There is protein in both the egg white and yolk. The eggshell also has protein components. There are at least 500 different proteins in eggshell, 200 in the egg white, and 300 in the yolk protein.



Albumen production occurs primarily in the magnum region of the oviduct.

Proteins and albumen

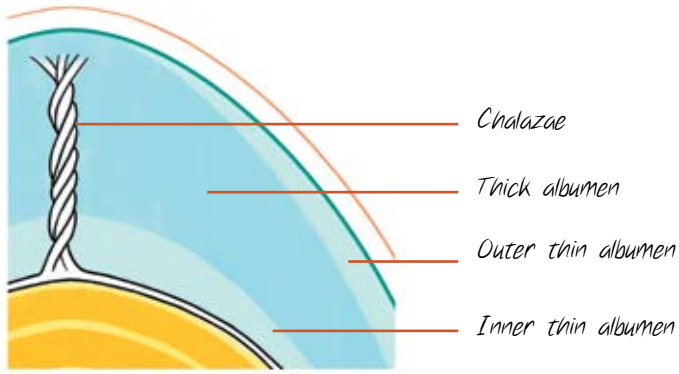
The albumen of eggs could be an important nutritional source of amino acids, the building blocks of proteins. Proteins have important functional roles in the human body:

- cellular metabolism
- DNA replication
- ion and molecule transport
- absorption of other nutrients
- anti-bacterial
- muscle formation, contraction, and relaxation
- provides firmness and elasticity in tissues
- promotes bone health
- improves memory
- production of antibodies
- regulates blood clotting

The function of many of the minor proteins and amino acids found in the albumen is still unknown. That is why egg related research is so important for both human nutrition and the pharmaceutical industry.

Foaming capability when whisked

Fresh egg white is easy to beat into foam, due to the ovomucins in the albumen. These albumen proteins form tiny strands which provide a firm structure. The egg white's foaming capability reduces as the pH rises. The egg white pH of fresh eggs is 7.6 to 8.5 and it has a murky colour , a sign of high carbonic acid content. After three weeks, the pH rises to 9.7, and the colour clears as the carbonic acid dissipates.



In a fresh egg, the egg white consists of the chalazae (3%), the inner thin albumen (17%), the thick albumen (57%), and an outer thin albumen (23%).

Ovomucin is important for a good gel formation (whipping). The pH is lower in fresh eggs, which makes them better for whipping.

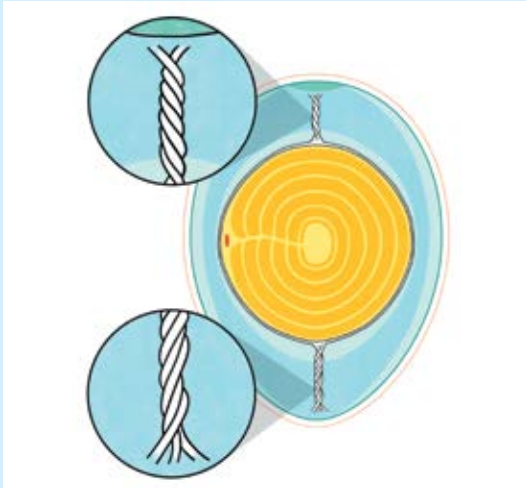
Albumen development

The chalazae form as the yolk passes from the first section of the oviduct (infundibulum) into the magnum region. The yolk turns constantly on its axis as it is moved by peristalsis through the magnum which is the longest section of the oviduct (38cm). As the yolk moves through the magnum the egg white proteins wrap around the yolk mass. The fibrous, strand-forming ovomucins give the albumen its gelatinous texture. The strands of ovomucin pull together as the egg spirals along the length of the magnum to form the thick albumen. This thick gelatinous layer separates the thin albumen into an inner and outer layer. In this way the three layers of the egg white are created. The outer thin white becomes thinner by addition of water and minerals in the isthmus.

A fresh egg. The chalazae is clearly visible. The egg yolk is transported through the oviduct in a spiral motion with the egg constantly rotating. Besides ensuring an even coating of the albumen, it also forms the chalazae by intertwining the proteins.

The oviduct walls consist of glands that produce the albumen proteins. This is then released and distributed by tiny 'brushes' around the yolk.

Egg rotation continues after laying. A hen rolls her eggs continuously during brooding. The goal is to prevent the yolk from sticking to the shell membranes. Poultry incubators mimic this rotation: eggs are turned 90° every few hours.



Chalazae

The chalazae are twisted strands of egg white which anchor the yolk in place, and stop it drifting. They form a fibre-like sheath around the yolk. Towards the pointed end of the egg three twisted strands of chalazae extend into and anchor the yolk into the thick albumen. Towards the blunt end of the egg another chalaza consisting of two strands anchor and bond the yolk to the inner shell membrane. You should always store eggs with the point downwards, because three strands are stronger than two. If an egg is eaten raw or is not fully cooked, the chalazae are tough and fibrous.

Volume

A lot of water is added in the isthmus, where also the shell membranes are formed, and that increases the volume of the albumen. In the isthmus, salts are added to the albumen proteins, this tensions the newly formed shell membranes, making the egg turgid while it still has no shell. In the uterus the egg will still 'grow' 30% because of water entering the membranes. Until the shell becomes rigid by calcium deposition. When calcium deposition is slow, the egg will grow even bigger.

Salty feed = large eggs

Salty feed will result in large eggs with poor shell quality. That is because the proteins in the albumen have moisture-attracting properties, like the crystals in a moisture absorber, and they grow as they absorb moisture. But the thick albumen actually becomes thinner as it is now more watery (lower Haugh Units). The eggshell forming on a watery albumen is also usually defective.

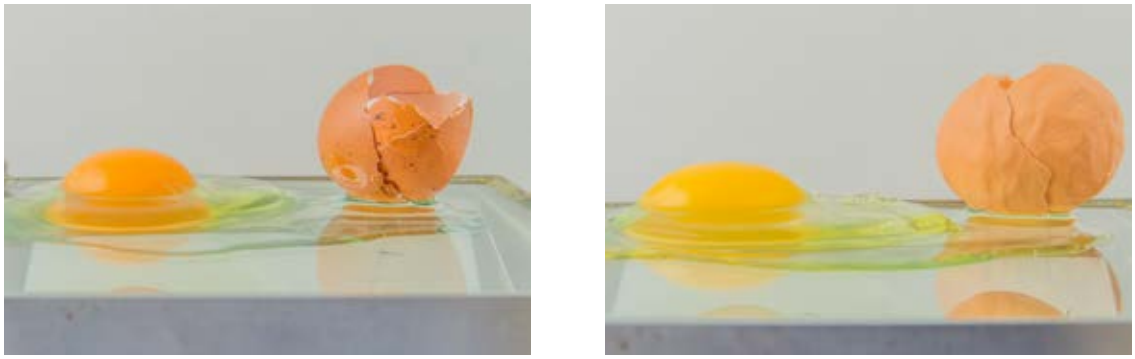
Signals from thick albumen

You can see quickly whether a hen is healthy or not from observing the thick albumen. A healthy hen has good thick albumen. A sick hen will have very little thick albumen and a lot of watery thin albumen. For example, a watery thick albumen is a signal of Infectious Bronchitis.

Natural preservatives

The protein lysozyme is one of protein components of thick albumen. Lysozyme, also found in human saliva, has the capability to weaken bacterial cell walls. A foodstuff preservative enzyme (E1105) is made by extracting lysozyme from chicken eggs. Lysozyme is used in baby foods, cheeses, meats, and for beer and wine production.

Since 2012, lysozyme is a permitted preservative for use in un-pasteurised beer in Europe. Lysozyme has an antibiotic effect and inhibits lactic acid bacteria growth.



The difference between a normal egg (left) and an IB-egg (right). The thick albumen of the IB-egg is a bit more spread out and the yolk is paler.

Thick albumen

One way to tell the freshness of an egg is by the height of the thick albumen. That is one of the points checked when a batch of eggs arrive at packing stations. The thick albumen's colour is another freshness indicator.

Methods for determining egg quality and freshness include measuring the height of the thick albumen. A micrometre gauge is the traditional tool used for measuring the height of the thick albumen. The measurement is usually taken close to the yolk. A calculation that takes account of the egg's weight is then computed and the albumen quality is expressed in terms of Haugh Units. The higher the Haugh Unit the better the quality of the albumen.

The formula for calculating Haugh Units is:

$HU = 100 * \log (h - 1.7w^{0.37} + 7.6)$

Wherein:

HU = Haugh Unit

h = thick albumen height in millimetres

w = egg weight in grams

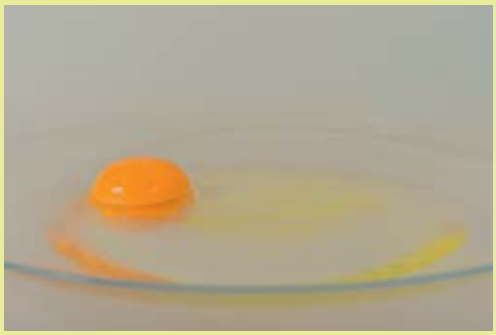
An old-fashioned Haugh Unit meter.

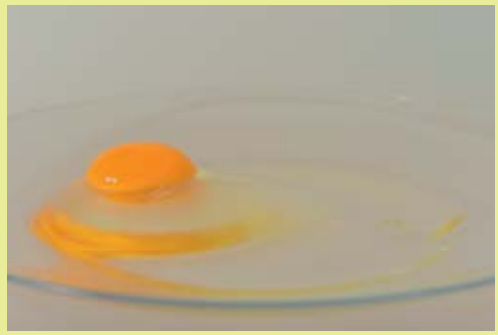
A modern digital Haugh Unit meter.

LOOK-THINK-ACT

What do I see?

Here, you see a fresh egg and an egg which has been stored for a while. You can see the difference in the thick albumen by cracking a raw egg onto a flat plate. The thick albumen will stand higher with a fresh egg, because the ovomucin fibres are still very firm.





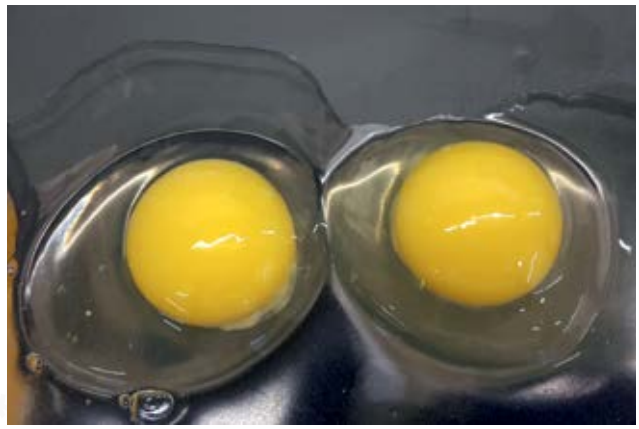
The colour of normal egg white

When you crack open a fresh egg, the albumen should be thick and gelatinous. It is not fully transparent, and even has a slightly murky colour. The carbon dioxide released after laying causes this effect. Older eggs which have been stored for a while become clearer and more transparent as the carbon dioxide levels diminish. This is normal.

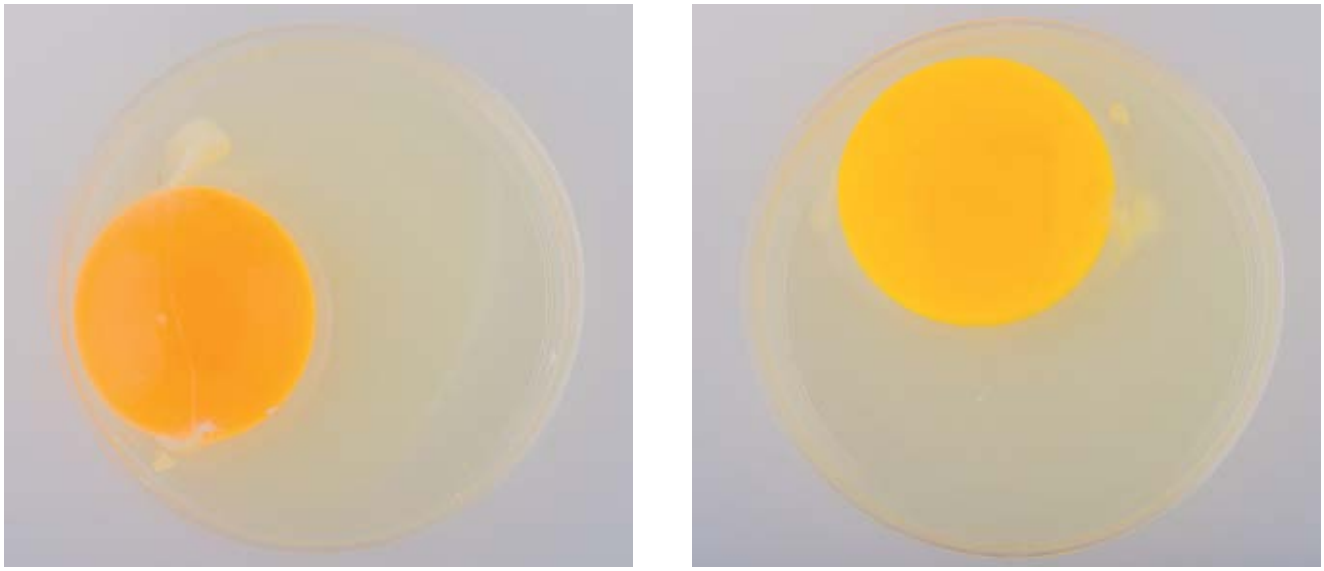
Glassy egg white

Sometimes fresh eggs can have very transparent, watery egg whites which appear glassy after boiling. This can occur irrespective of flock age as a result of diseases such as Infectious Bronchitis (IB), Infectious Laryngotracheitis (ILT), Egg Drop Syndrome (EDS), or because of excessive house ammonia or too much vanadium in the feed (vital for healthy growth, but in small doses). Or as a result of heat stress causing the animal to drink a lot of water with a decreased feed intake.

Nice fresh eggs with high thick white and clear chalazae. Some consumers seem to think that the chalazae are semen from a cockerel. It is better for people with that opinion to fry eggs that are at least a week old, because the chalazae are no longer visible then.



The egg on the right shows a slightly opaque egg white.



You can see the slightly murky colour very clearly in freshly laid eggs from young hens (left). This colour effect diminishes, as hens get older (right).

Inclusions in the egg white

An egg's contents should look fresh and clean. Sometimes, you find inclusions, such as blood or meat spots.

Many consumers think that the egg is fertilised if they see blood or meat spots. But that is seldom the case. In fact, in most production systems, no cockerels are kept. Any remaining cockerels are usually removed when pullets are transferred from rearing unit to laying house. Occasionally one may be missed, which leads to some eggs becoming fertilised. A cockerel is easy to detect during laying, because you can hear him crowing.

The situation however is different in some organic systems. In those systems cockerels make up at least one per cent of the flock. This ensures peace in the flock and more natural behaviour, with associated welfare improvement. Eggs from these systems are stored in cold stores, to ensure that the embryos do not develop.

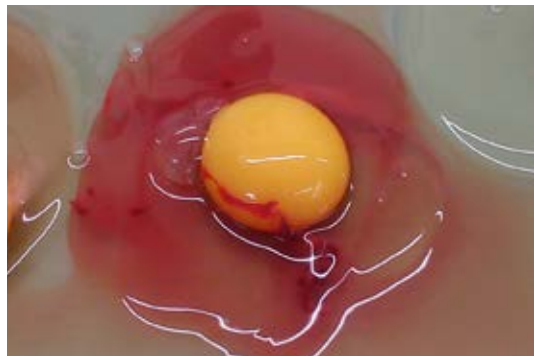
The cause of blood spots

The stage of development of the egg yolk in the ovary varies. Each developing follicle or yolk sac is connected to the wall of the ovary by a stalk which holds it in position. The wall of the yolk sac has a very good blood supply all over, with the exception of a single seam (the stigma). When the yolk has fully developed, the sac bursts at this point to release the yolk. If the yolk sac opens at another place where blood vessels are present, a little bleeding will occur and the blood will accompany the yolk mass into the oviduct. This is how blood spots form. Some strains are more susceptible to blood spots formation but stress and disease can also influence it. Blood spots most often occur on the outside of the yolk, because the haemorrhages occur when the yolk is released from the ovary. If they occur in the albumen, then the haemorrhaging has occurred at a later stage, in the oviduct. Sometimes they are red in colour, other times they appear brown.

Small meat spots in the albumen are not unusual.

A large blood clot in the albumen, with leaking blood through a burst blood vessel during albumen formation.

Not all inclusions in an egg are blood or meat. This is simply a little yolk material in the chalaza.



There can also be diffuse blood in the albumen that gives the albumen a pink appearance.

The cause of meat spots

Meat spots occur mainly through inclusion of bits of tissue which has sloughed off either from the ovary or the oviduct. They most often occur in older birds.
Most often, you see inclusions in eggs from older brown egg layers. Another possibility is a blood spot that has almost broken down. Inclusions are an inherited factor, and breeding companies select strictly to eliminate it.

The occurrence of many meat- or blood spots is a signal that something has gone wrong, disquiet or disease in the flock. Other causes include mouldy, or otherwise inadequate, feed, the wrong lighting schedule (i.e. continuous lighting or intermittent periods), or other stress factors.

Meat spots are mainly brown in colour, and you see them primarily in the thick albumen, chalazae, or yolk. Their size can vary from 0.5 to 3 mm.

A very large meat spot in the albumen.

On-farm egg storage

The storage conditions of eggs have great influence on the quality of the albumen. This starts at the poultry farm. Certainly under hot and dry conditions, it is important to store the eggs in an air-conditioned store room. As the age of the flock advances albumen is never as good as it is in a young flock, Poor on-farm storage will result in poor albumen quality.
Optimal is a separate insulated storage room with a temperature of 15°C and a relative humidity of 70-75%.

Proper storage conditions prevent unnecessary loss of quality.

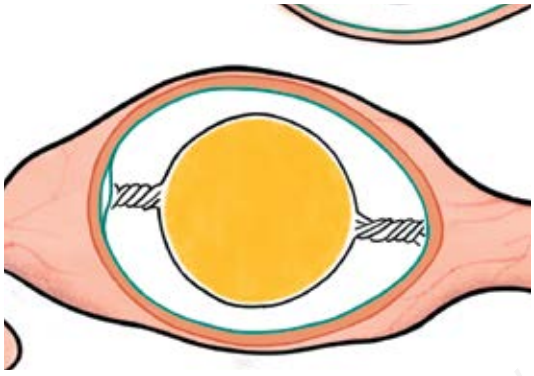
CHAPTER 6:

The eggshell

It takes the hen twenty hours to form the eggshell. What a shame if this effort is wasted if the egg breaks along the way.

An eggshell is a very exceptional thing. It ensures a protective environment for the chick. It is strong enough to bear the weight of a brooding hen, yet, it has a construction that allows the chick to absorb calcium from it for bone formation, and then allows the chick to break through at hatching. It protects the egg contents from bacteria, but allows, gaseous exchange between the inside of the egg and the outside world.

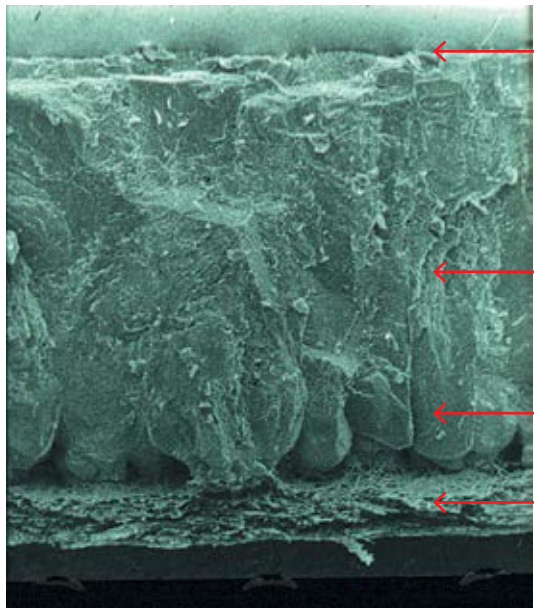
An eggshell is a bit like an igloo. An igloo is hard and cold on the outside, and its dome shape makes it strong. Yet, it is easy to break through from the inside, and higher temperature makes it softer here too. In an eggshell, it is not so much a case of temperature differences which vary its properties from the inside to outside, but differences in structure between the inside and the outside of the shell. When the egg contents are removed and the shells no longer serve as packaging, they can be reused as a raw material for other purposes, e.g. high-class cosmetics, osteoporosis drugs, lime fertilisers, and feed (e.g. pecking stones).



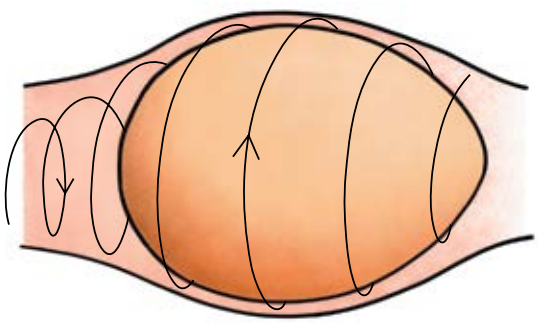
Shell formation occurs in the uterus.

Built in layers

Shell formation starts with tensioning the shell membranes. Small, calcified dots appear and anchor onto the outer shell membrane. These points form the nucleus or seeds from which the other calcified layers develop. Calcium forms in a radial fashion around these sites and continues to grow outwards and upwards until adjacent nucleation points meet and then grow together. Gaseous exchange pores form at spots where these nucleation sites do not grow together. The calcium salts deposit onto an organic framework which consists primarily of proteins. This framework strengthens the forming shell, acting as a sort of reinforcement or adhesive. The initial stages of shell formation gives rise to regular knobbly points (mammilla) on the outside of the shell membranes. In combination, these points and pores between them form a closed layer, (the mammillary layer). The mammillae are firmly anchored in the shell membrane. The next stage of shell formation gives rise to the bulk of the shell thickness. The shell is formed more rapidly during this phase by the simultaneous deposition of both the mineral and organic matrix components of the shell. The resulting palisade layer is spongy and makes up about 60% of the eggshell's thickness. Finally a thin outer, phosphorus-rich, vertical, crystal layer forms, followed by the deposition of the eggshell's bloom (cuticle).



A section of eggshell as seen through an electron microscope.



To allow formation of a beautifully even shell, the egg rotates continuously in the uterus. Meanwhile, calcium salts start to form crystals at specific sites on the surface of the outer shell membrane. The size and orientation of these crystals is influenced by the presence of proteins in the fluid bathing the egg. These proteins are released from the cells lining the uterus.

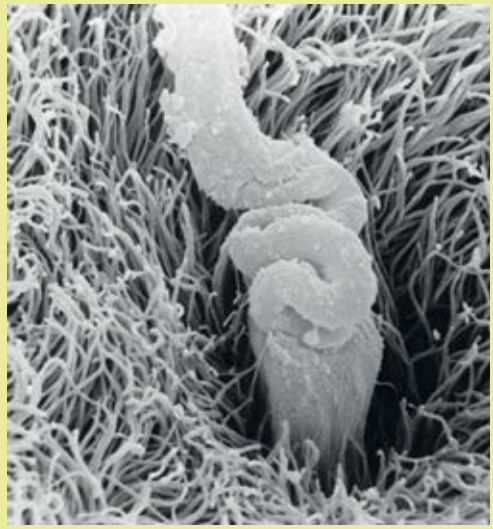
Eggshell thickness

The thickness of the eggshell depends on the length of time the egg spends in the shell forming section of the oviduct, and the availability of calcium delivered to this region during shell formation. A hen produces a fairly constant quantity of eggshell material each day, regardless of egg size. Shell thickness tends to decrease with the hen's age, because the eggs get bigger. You can promote shell thickness restoration through a moulting period. The average chicken eggshell thickness is 0.3 to 0.4 mm. On the left an old shell thickness meter, on the right a modern version.

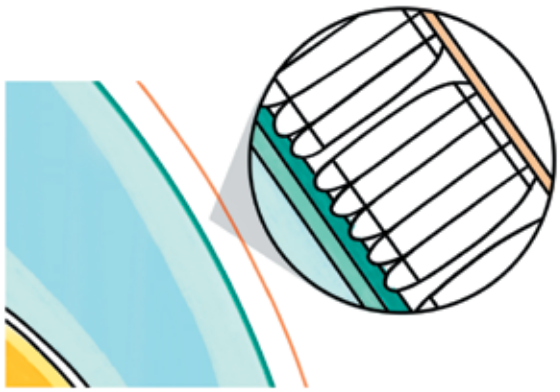
Shell membranes determine eggshell structure

The shell membranes look like two parchment-like layers surrounding the egg contents. The inner shell membrane enrobes the egg white and is directly in contact with the outer thin albumen The inner layer of the inner shell membrane is initially very thin anchored to the albumen. The inside layer is often thicker in older eggs and more loosely attached to the egg white. The fibres on each membrane are so intermingled that it is difficult to differentiate between them. With the exception of the blunt end where they are separated by the airspace.

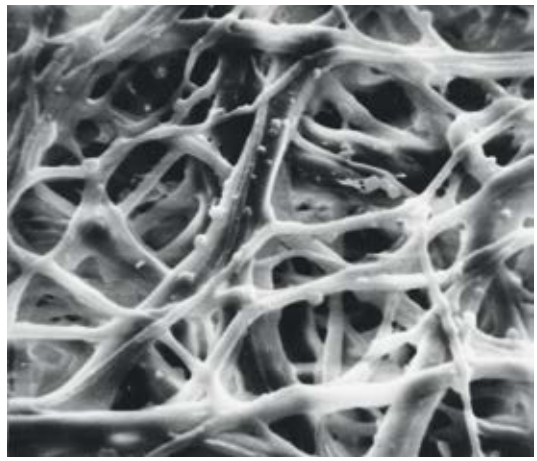
The shell membranes have a tough texture and contain keratin. If the shell membranes are defective, the eggshell will have a weak structure.



The surface of the isthmus region of the oviduct. Little glands produce slivers of protein to form the shell membrane. Glands under the hairlike structure exude more chalky substances as the egg passes over them. Left – 300 times enlargement. Right – the same gland magnified by 3000.



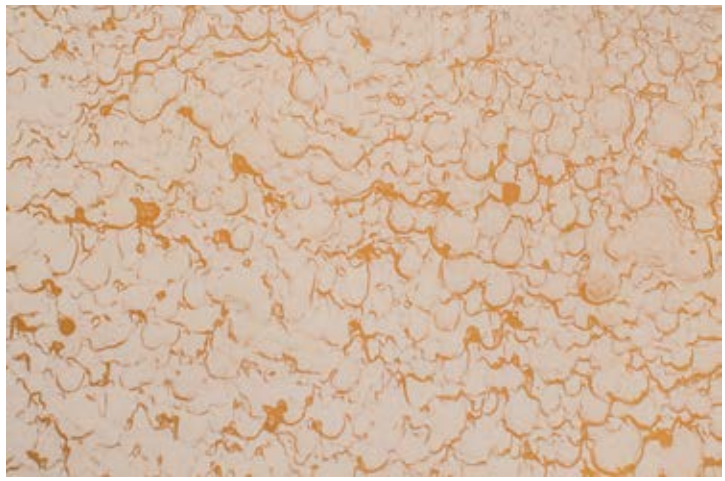
The outer shell membrane fibres are almost indistinguishable from the eggshell, because they are so tightly attached to the shell. That is why sometimes you can still peel an egg and keep the shell in one piece.



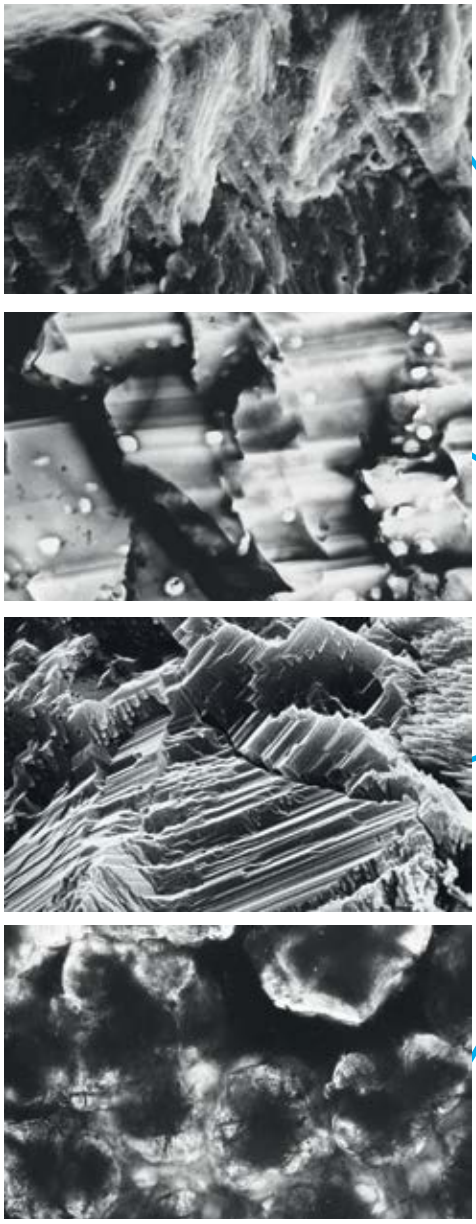
Shell membrane under an electron microscope. The protein fibres make the shell membranes very tough.

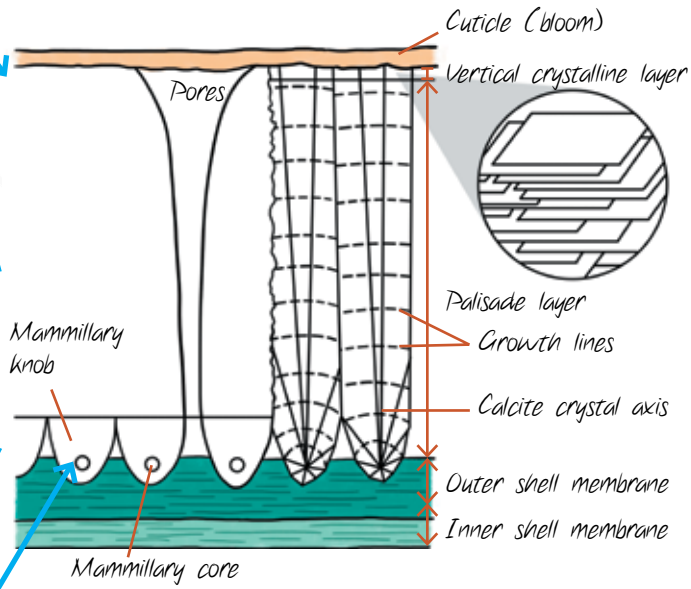
Making eggshells is night work

Building up shell on the membranes takes twenty hours, which makes it by far the lengthiest part of egg formation (apart from yolk creation). The calcification is slow during the first five hours, then fast for ten hours, followed by another five hours at a slower tempo. Chickens lay mainly in the mornings, and that makes the end of the previous day and overnight the most important period for shell formation. Make sure your hens have enough calcium to support shell formation, particularly towards the end of the day, and make sure that they get enough rest, to avoid any disruption to the process.



The surface of an eggshell close up (enlargement 20 000 times) Eggshell 'construction' occurs mainly during the last five hours of the day and the first 5 of the night. Ensure that at least 50% of the required calcium uptake is available during that period.





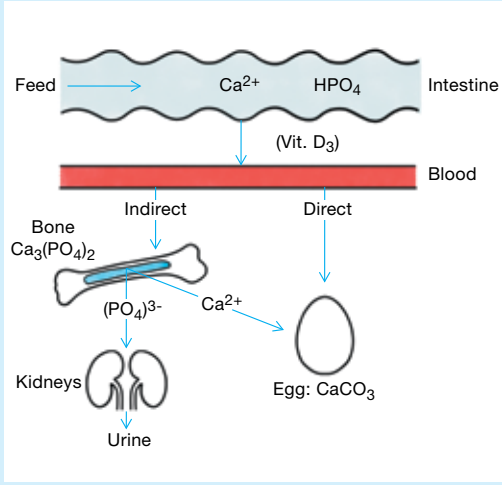
The mammillary or foundation layer of the shell with its many crystals is anchored onto the outer shell membrane. If the foundation layer is good, it is easy to continue building a good construction. The quality of anchoring is partly genetically determined. Environmental stress, disease, and age can have a powerful influence on it.

Plenty of calcium makes strong eggs

Creating eggs with strong shells requires quite a lot of calcium. The hen can source calcium in a couple of ways, either from the feed or from her bones (principally medullary bone), and will use both to produce a strong egg. It is very important to provide enough calcium in the diet to ensure that the hen absorbs as little as possible from her bones, as this is a less energy-efficient method of providing calcium. Normally about 30% of the calcium required to form an eggshell comes from the bones the rest comes from the food in the intestine. After laying an egg, the medullary bone is usually restored, ready for the next egg. Thus, the medullary bones acts as a sort of buffer. But the restoration of medullary bone is not 100% efficient and over time calcium is also withdrawn from other types of bone which can result in osteoporosis, especially if the hen does not have sufficient opportunity to exercise.

Calcium sources – direct and indirect

A hen can take calcium through an indirect route, i.e. from her bones, or she can obtain calcium directly from her feed, through the bloodstream. The latter is the best way for the chicken. That is why you should supply extra calcium in the afternoon and evening. It makes a difference if you use calcium in the feed that is highly soluble (chalk or fine limestone chips) or a type with slow solubility (coarse limestone or seashells). Provide hens with a quickly soluble calcium source while they are forming eggshell. Otherwise, it will be stored in the bones and used indirectly later.
The best option is to provide both a highly soluble limestone and a coarser form e.g. oyster shell - the former is then used up efficiently whilst the latter is available for during the dark period, thus the hen is without a dietary source of calcium for less time. Particle size is also relevant: over 2 mm is advised.



LOOK-THINK-ACT

What is wrong with this hen?

She has weak bones with risk of fractures. This is known as 'cage-layer fatigue' or osteoporosis. Too little physical exercise, insufficient calcium absorption, or both, lead to hen osteoporosis. Hens jump all through the day in aviary systems, ensuring good blood circulation to the bones. These hens from this type of system have stronger bones and stronger eggshells at the end of the laying period.

Photo: I. Dinev and CEVA

Is the calcium supply good enough?

Hens need to have the opportunity to select calcium particles, so that they can take the amount they require. The size of particles is thus very important. They must be at least 2 mm for optimal absorbability of the calcium. You should let your hens eat the feed trough empty once per day. But you should do that late in the morning or early in the afternoon and not in the evening to ensure that the birds have sufficient available calcium in their body for eggshell formation.

Methods of providing calcium

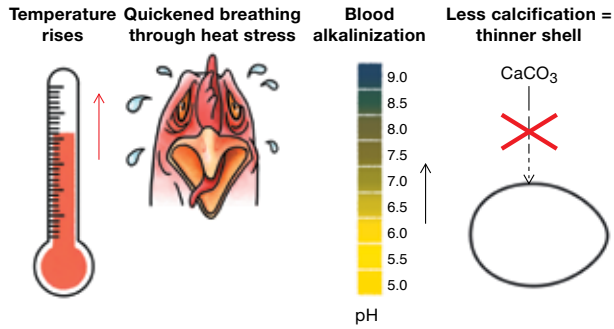
Oyster shell is a good source of calcium. You can provide it in different ways:

1. in a standard feed mix
2. scattered over the feed, like a topping (added into the hopper)
3. scattering larger chips in the house

At the end of the day, check the feed trough for visible black spots. This means the calcium supply is sufficient. If there are no black particles left, the hens have taken all the calcium, and there may be a shortfall. There should always be some left. Repeat the check in the mornings.

In this feed the black coloured calcium particles are clearly visible.

Heat stress and shell thickness



The birds eat less in high temperatures and the onset of heat stress. Their increased respiration rate causes CO_2 expiration. The blood become more alkaline and in order to restore the acid-base imbalance HCO_3^- is required, making it less available for egg shell calcification ($CaCO_3$). These are two reasons why the shells becomes thinner. If high temperatures are expected, feed extra sodium bicarbonate and supplement vitamin C in the water lines (150 g per 1,000 litres) to combat reduced calcification.

A pecking stone contains useful minerals, but also calcium.

A system for scattering grains can also be used for calcium supply.

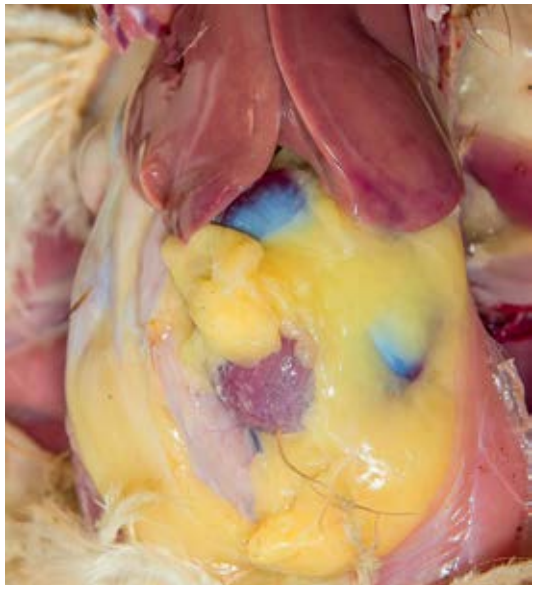
Taking calcium from the bones can lead to fractures

The phenomenon known as 'cage-layer fatigue' can also occur when hens absorb too much calcium from their bones for eggshell formation. The bone loss can be up to 10% of the hen's body weight which makes the bones too brittle. Likely, there was too little (absorbable) calcium in the feed. Each egg requires 2.2 to 2.3 grams of calcium. A hen needs to eat twice that amount daily as she can only absorb about 60% of her dietary calcium. Ensure that the hens can take up enough calcium, combined with phosphorous and make sure that the hens have enough physical exercise for good blood circulation to the bones.

Calcium supply and fat hens

If there is insufficient calcium in the feed (less than 4% with older hens starting week 55), hens will try to compensate by eating more. The extra feed consumption will lead to them making more fatty tissue and producing eggs with big yolks. The fatty tissue will also form around the reproduction system, which will lead to lower egg production. Definitely not what we want! Make sure there is more than 4% calcium in the feed, especially if there is no calcium oyster shell supplement.

Hens in aviary systems move a lot, which is excellent for bone-tissue blood circulation. That ensures good bone health and protects the bird from developing osteoporosis and consequently, weak shells.



Too little calcium causes fat deposition. Here seen on the reproductive organs.

During the period it takes to form an eggshell, the middle ten hours which occur at the end of the day and first part of the night, are very important. Make sure the hens have peace during that period.

Go back in time

Eggshell abnormalities can be a reflection of an incident that occurred sometime during the twenty-hour egg formation period. It could be a feed problem, stress, or disease. If you see many abnormal eggs, try to find the cause quickly. And talk to your feed supplier.

Shell strength

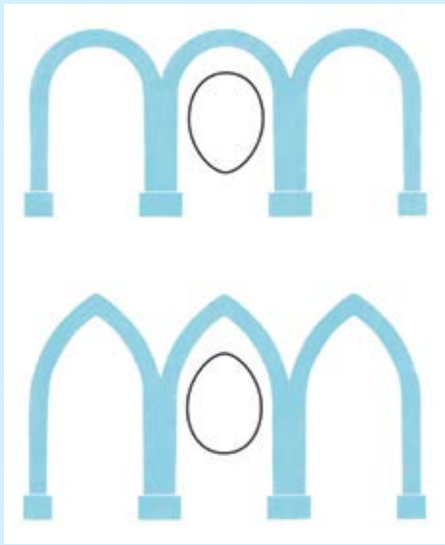
Besides calcium availability, the structure and shape of the egg are also determining factors of shell strength. The optimum egg shape is extremely strong! But the shell must still be thin enough for the chick to break through after absorbing the inner part to form its own skeleton. It is easier for a chick to break through the shell at the blunt end of the egg. This is where the air chamber forms. There are comparably more gaseous pores there too.

Is the overall thickness even?

A normal egg shows little variation in shell thickness. It varies from pole to pole, but tends to be consistent around any latitude. With extra thick eggshells, you see thicker shell at the point.
We express shell strength, or more correctly, breaking strength, in Newtons, the force that can be applied before the shell breaks. In practice, weak shells result in hairline cracks or leaky eggs. Once the breaking strength of eggs from a flock decreases, it will never return to its former level.

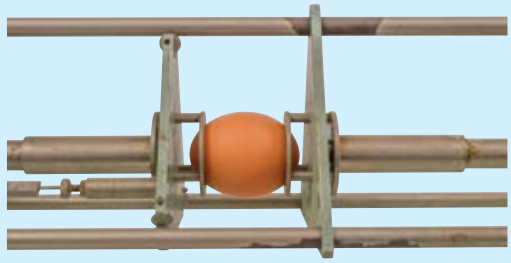
Cracks might be due to a decreased shell strenght and can be detected by candling.

Strength through the right curves



In general, the shell is not necessarily thicker at the point or the blunt end, but the different curvature makes those parts stronger. You can see the same difference in Gothic or Roman arches. Gothic arches were more pointed, and thus stronger than the rounder Roman ones. An egg is weaker if it is compressed at the equator than it is if it is compressed from pole to pole.

Measuring shell strength



You can test eggshell strength with a breaking strength meter. There are various types of meter. In the method described here, the egg is laid on its side between two parallel steel plates. The plates are squeezed together at a steady rate. The egg resists the force until it cracks. Here we record how the egg distorts. The distortion is dependent on the shell's thickness, curvature, diameter, and the structure of the individual layers in the eggshell. We express egg strength in Newtons.

Differences in shell strength

In general, brown eggs are stronger than white ones. Shape and shell thickness can also play a role in shell strength. But that does not apply to all breeds. Eggs laid early in the laying period are stronger than later ones, as older hens lay bigger eggs. But you get stronger eggs again after a moulting period. However, eggs laid early in the period by a breed with weaker shells are always stronger than eggs produced later on by a breed with strong shells. And thus, genetics is not the only important factor. Brown eggs can possibly have slightly thicker shells and be rounder than white ones. But white shells may have a different and firmer shell structure. Variations between breeds are generally greater than the differences between brown and white. In addition, it depends on when the hen lays the egg during her approximately fifty-day laying series. Hens cease laying for a day before starting the following laying series. The first and last eggs in a series seem to be the strongest.

The relationship between low breaking strength and hairline cracks/leaky eggs

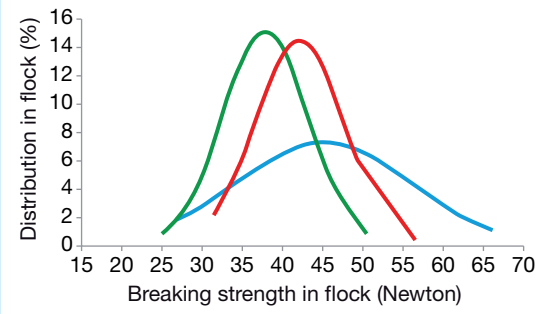
Breaking strength (N)	Hairline cracks (%)	Leaky eggs (%)
38 N	3%	0.1%
36 N	6%	0.4%
34 N	8%	0.8%

How can you influence the breaking strength?

1. Sufficient calcium in the feed (Phase 2, 4% – Phase 3, 4.3%)
2. More than 50% of the time that feed is available in the last 5 hours of the day.
3. Extra oyster shell or limestone chips
4. Extra vitamin D3 (or even better, OH-D3)
5. Make sure there is always some feed and calcium supplement in the feed trough when the light comes on.
6. Make sure the feed trough is empty around midday and provide calcium-rich feed in the afternoon.
7. Maintain house temperature under 23°C.
8. Extra ventilation (to prevent high relative humidity and/or ammonia levels).

If the feed trough is empty at around midday, you are sure that the hens have taken up all the calcium in the feed. Some poultry farmers use a different feed composition with higher calcium content in the afternoon. The calcium requirement is higher in the evening.

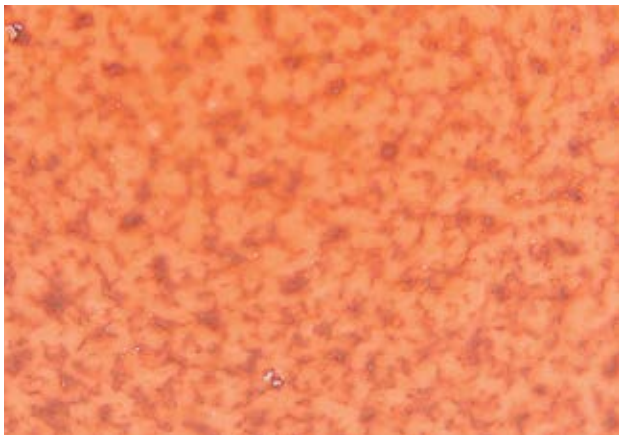
Breaking strength in a flock



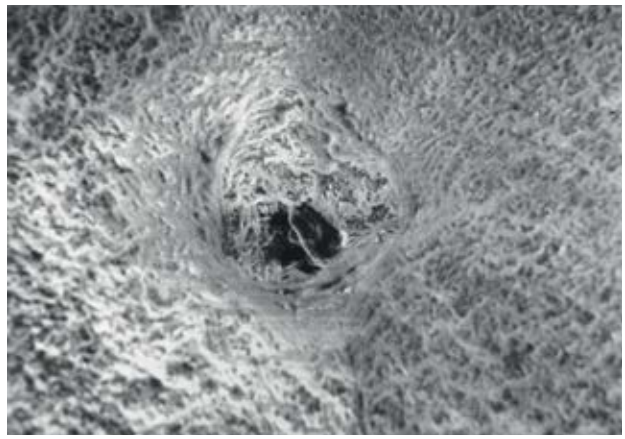
Breaking strength has high heritability. In the graph the breaking strength of the 'blue' strain is on average higher than the other flocks (peak at 45 Newton), but there is more spread around the average (from 26 to 65 Newton: less uniformity).
The 'red' strain has a better uniformity but a lower breaking strength (42 Newtons). The red line on the right is a young flock. The green line on the left is a flock of the same strain after a moulting period, with an average breaking strength of 38 Newton.

Pores for gas exchange

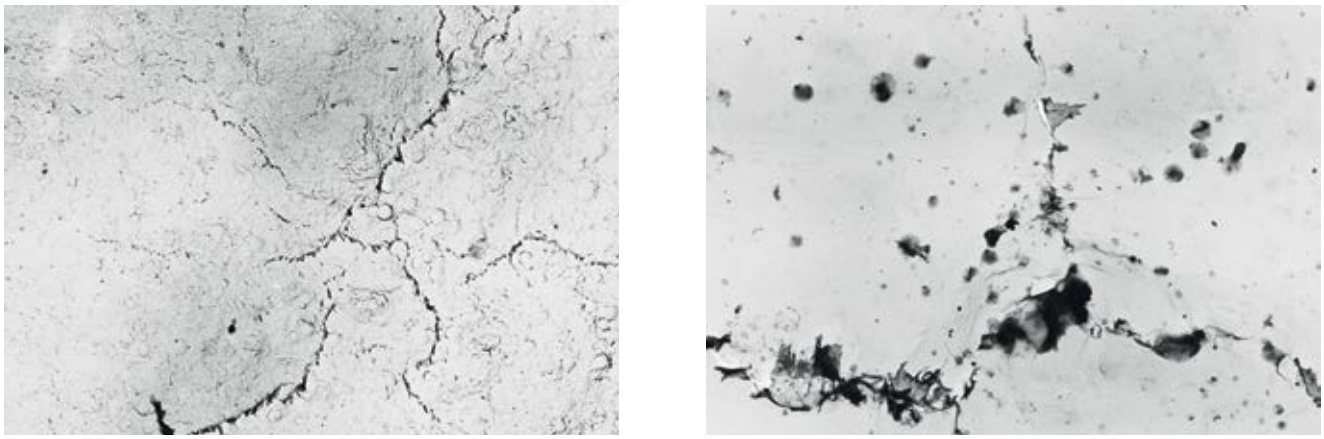
An eggshell must be porous enough for the chick to breath, while at the same time prevent excessive moisture loss. It should also prevent bacteria getting in. That is why an egg has around 10,000 pores, which are partially filled with cuticle, a protective layer which forms over the surface of the eggshell. This layer has no visible opening but it still allows gasses through. The cuticle thickness is between 0.010 mm and 0.005 mm.



The most numerous and largest pores are at the blunt end of the eggshell. That is also the spot where the chick takes its first breath of air prior to hatching.



All the pores on an egg take up only two square millimetres of its surface. In other words, they are exceptionally small. If you wash an egg, (warm) water may possibly damage the protective layer of cuticle, which then allows bacteria to gain access to the gaseous exchange pores.



The surface of the eggshell magnified 6000 times. Left – a fresh egg that shows the surface with very small, hairline, cracks. Right – an egg which has been stored for a couple of months; the cuticle has become smoother and the cracks have developed into deep fissures.

Egg colour

In general, you can tell which colour eggs a hen will lay from its earlobes. It is a genetic factor. The older the hen, the lighter the egg is. In many countries, darker eggs are more expensive than lighter ones. There is also an additional and very practical advantage with brown eggs; you can easily see that you have removed every trace of shell when peeling them!

The eggshell colour pigments form in the gall bladder.

Egg with various pigment variations. The shell itself is normal (no extra calcium depositions).

Small pigment spots – The pigment builds up especially in the deeper points on the eggshell surface (e.g. the pores).

Larger pigment spots.

Pigment spots on a white egg.

A very unusually coloured egg. Possibly the black colour originated from coagulated blood.

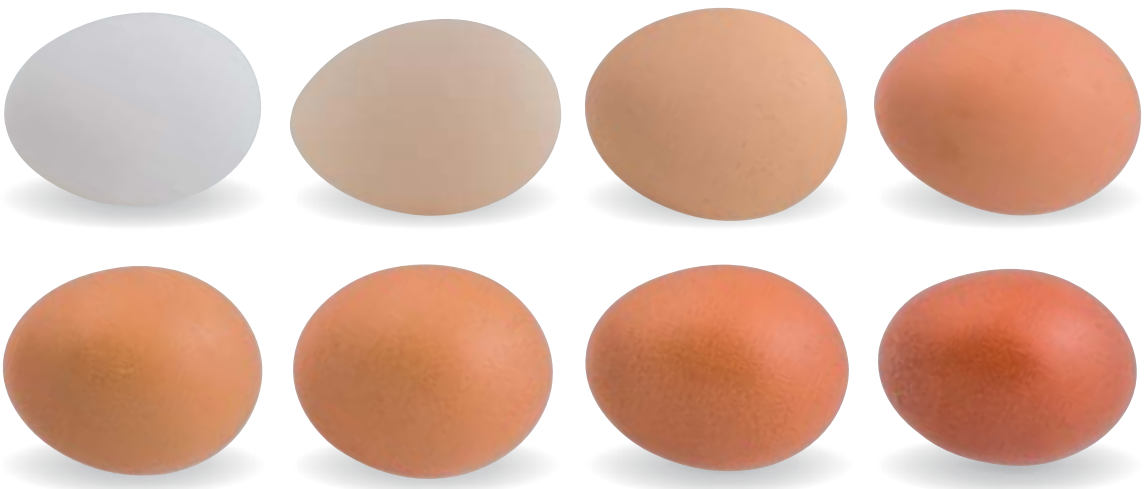
The shell colour fan

Shell colour is genetically determined and therefore strain specific. Yet, within a flock you still see considerable variation in shell colour. The colour in itself is not very interesting. The unexplained variation in the flock is more important.
A colour swatch fan has been developed for objective comparison of shell colour. Colour variations within a flock can have many causes.
Packing stations have the technology to sort eggs so that all the eggs in each pack have the same colour, but that is rarely done.

Sometimes you can see a relationship between production levels and shell colour. The more eggs a hen lays, the lighter the shell colour. Perhaps it is a question of the hen having a limited 'paint supply'. But there are also certain strains that are very good layers and still maintain a dark brown colour up to the end of the laying cycle, e.g. the Maran.
Brown eggs often have stronger shells than white ones. Brown eggs have a thicker cuticle because there is also some pigment in it.

You can use a special swatch fan to determine shell colour.

Shell colour measurement used for breeding research.



Consumers preference for a certain shell colour is a cultural factor and varies by country.

The colours of the shell colour fan. This is just an indication. For a proper assessment you should use a real shell colour fan.

Causes of pale eggs

- **Genetics:** the colour of eggs is genetically determined, but within a strain and flock there is always some variation.
- **Disease:** some diseases damage the oviduct and affect egg production. IB is the most important one regarding the influence on shell colour.
- **Nutrition:** nutrition has little effect on shell colour. However, nutrient deficiencies can influence the total process of egg development, including the shell. Certain drugs create pale eggs (sulphonamides, nicarbazin). 5 mg nicarbazin per day, results in white eggs within 24 hours.
- **Age:** pale eggs are more common in old flocks. Egg size increases with age and the same amount of pigment is dispersed over a larger surface area. Very light shells may occur due to premature termination of shell pigmentation. If brown-egg flocks are moulted, shell colour is usually darker after the moult than before.
- **Stress:** Three to four hours before laying, the bulk of the pigment is transferred to the cuticle. A premature egg may not have had enough pigment deposited. If the egg is retained longer in the oviduct because of stress, this might cause a thin layer of calcium being deposited, giving the egg a greyish, bleached-out look (see page 86).
- **Parasites:** infestation with roundworms or capillaria worms may cause pale shell and pale yolks, due to damage of the intestinal walls, reducing nutrient absorption necessary for egg development.
- **Sunlight:** pale eggs occur more in free range flocks than in closed houses. The reason is not exactly known. Increase vitamin D3 production by the hen due to exposure to sunlight, combined with vitamin D3 in the ration, could be a reason (an overdose of vit. D3).

LOOK-THINK-ACT

Suddenly a different egg colour?

Sometimes a hen that lays brown eggs suddenly lays a white one. If that happens with the whole flock at once, it could be caused by coccidiostats (nicarbazin) in the feed.

Egg finish

The eggshell gets a layer of 'paint' and then a coat of 'varnish'. The pigment is already in the last layer of the shell, which then gets a coat of cuticle (bloom) also with pigments in it. That last layer ensures smoothness, strength, and protection. This happens during the last 6 hours before laying. In general brown eggs are stronger than white eggs, but there are large differences between breeds.

Difference between brown and white eggs

White eggs are not necessarily bigger. In fact the smaller white eggs (S and M) are more liable to be processed and so do not readily make it to the supermarket shelves. In countries such as Germany, coloured boiled eggs are sold throughout the year, and to paint, you need white eggs. A white egg can be peeled more easily because of its more compact shell structure.

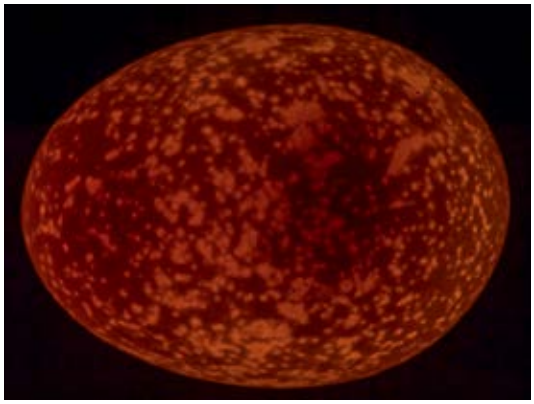
There are more inclusions found in dark brown eggs than in light-coloured ones. This is because the inclusions are more difficult to spot using detection equipment.

Poultry farmers also have their preferences. White hens are somewhat more easily agitated, but they lay much more efficiently and so at a lower cost per egg. They lay 20 or more extra eggs during a laying period and eat 5 grams of feed less per day. Poultry farmers doing home sales in the Netherlands tend to opt more for brown-laying breeds.

Some strains lay green or blue eggs. The funny thing is that the shell of a green or blue egg is completely green or blue – not just the outer layer. So another factor has come into play here in comparison to normal white-egg-laying and brown-egg-laying animals.

Colour variations within a flock

If you see colour variations in eggs from a flock housed indoors, you should consider quickly whether any pale eggs might be the result of a viral infection. It could be TRT virus, ND, IB, or AI. Sometimes vaccinations can also cause a temporary reduction in shell colour. Diagnostic research can help to clarify what's going on. Make sure the hens' resistance is up to standard, and that the necessary vaccinations have been carried out. Also check for any irregularities in the feed. Shell colour variation within free range or organic flock is quite common and unless there is an abrupt change from the norm, it is usually not indicative of a big problem.



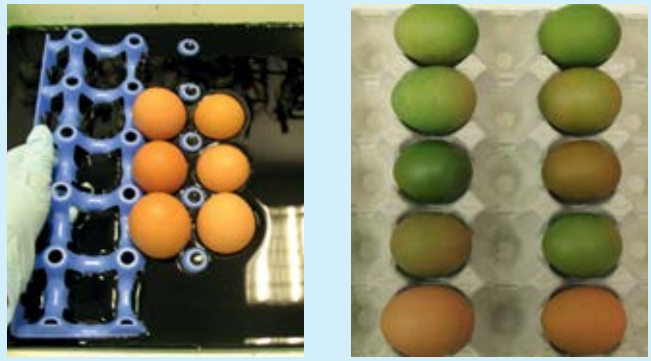
If you place an egg in front of a candling lamp, you sometimes see a spotted shell (mottled eggshell). The cause is local areas of thin cuticle or an abnormality in the shell structure that allows moisture to penetrate into the calcified layer and weaken the shell. High humidity in the housing will increase this problem.

Cuticle

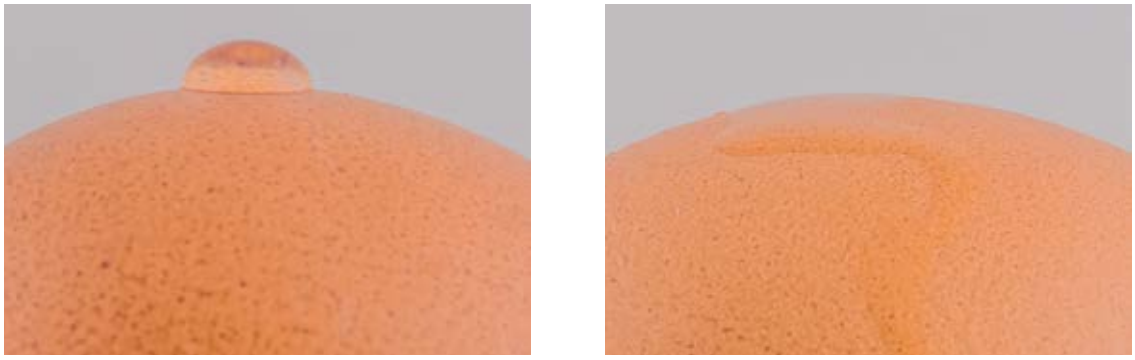
Previously, eggs had a thicker cuticle than they have nowadays. Clearly, higher production leads to diminished finish quality. Through breeding selection for long series of eggs, hens now have fewer 'rest days' than previously. Breeding companies are now able to select for improved cuticle quality and reverse this trend. A cuticle is important in order to protect the egg contents against invading bacteria and fungi.

Making the cuticle visible

You canot see the cuticle but you can make it visible by dyeing it. The thicker the cuticle, the more colourant it can hold. In this manner, the quality can also be made visible. In this way it was discovered that cuticle thickness is hereditary and can therefore be selected ($h^2 = 0.27$). Because a part of the egg colour resides in the cuticle, the breeding program automatically selects brown eggs based on the cuticle thickness.



Eggs are dipped in a colouring solution (left) to make the cuticle visible. The intensity of the green colouring provides an indication of cuticle thickness - the darker the green, the thicker the cuticle (right).

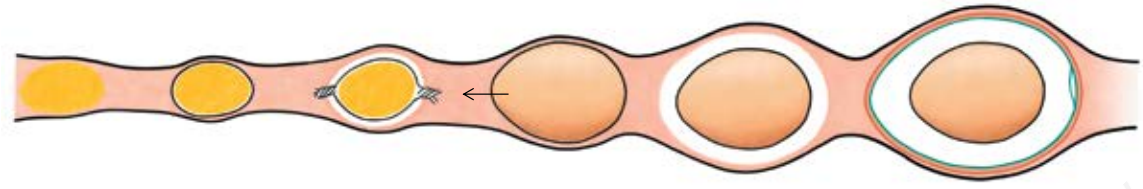


The cuticle is a waxy layer. You can see that after washing the egg shell. On the left with complete cuticle: the drop of water lies on top of the egg. On the right without the cuticle: the water runs off the egg (and could enter through the pores).

A strange phenomenon – An egg within an egg

A completely formed egg inside another egg. This phenomenon sometimes occurs among young hens. Explanation: An already completed egg has stayed in the oviduct too long, possibly because of stress or irregular production with frequent ovulations. The egg then gets sucked back into the oviduct, where it ends up next to the following yolk. The complete egg subsequently gets enrobed with albumen, shell membranes, and a new shell along with the new yolk. Sometimes the system sees the completed egg as the new yolk resulting in the outer egg having no yolk. To minimise this type of abnormality it is best to try to prevent stress and ensure peace and quiet around laying time. An egg-in-an-egg is a rare occurrence. The chance is less than one in a million.

An x-ray of an egg-in-an-egg. This is not trick-photography.



This illustration shows the cause of an egg-in-an-egg. A completed egg stays too long in the oviduct, is sucked backwards, and the next one follows too quickly.

An egg with no shell

Soft shelled eggs and shell-less eggs, occur at a rate of 0.5% to 6% of the total egg production, and are especially common in young hens that start laying too early. It is often thought that a calcium deficiency is the cause, but that usually causes weak, thin shells. Soft shelled eggs occur because their yolks are released from the ovary in quick succession and are released from the oviduct before there is time for shell formation. The oviduct cannot handle the quick sequence of egg release. Other factors that cause soft shelled eggs or shell-less eggs include high temperature in the house (quick breathing causes acidification in the blood, and that leads to poorer calcium metabolism), stress, or disease (e.g. EDS).

Soft shelled egg. There is some shell formation, but too little to give it any strength.

Suddenly fewer eggs?

Sometimes it seems that the hens are laying fewer eggs. EDS (Egg Drop Syndrome) might be the cause. EDS occurs occasionally, especially during the first months in lay, with heavier strains (brown laying hens). The cause is a virus that attacks the cells of the shell gland or uterus that produces the eggshell. The virus inhibits the shell gland from doing its job, which in turn causes soft shelled eggs to be laid. There is no actual drop in egg production with EDS, but it can appear to drop because the hens often eat their shell-less eggs. You may also see a significant number of yolks on the manure belt (the egg white is transparent so not easy to detect). The virus spreads slowly, and primarily in floor housing. Preventive vaccination is possible. Unfortunately there is no treatment.

Young flocks ovulate sometimes fast and frequent and lay relatively more shell-less eggs. But these often turn out to be very productive flocks. Poultry farmers tend to say about a starting flock with many shell-less eggs: 'This will be a good flock!'

LOOK-THINK-ACT

What causes a wet nest box?

A lot of wet mess in a nest box. This can be a signal that there are soft shelled or shell-less eggs being produced. Sometimes, it is difficult to notice these eggs, because many do not get onto the egg belt. Hens like to eat shell-less eggs. They are also easily trampled, causing a wet nest box.

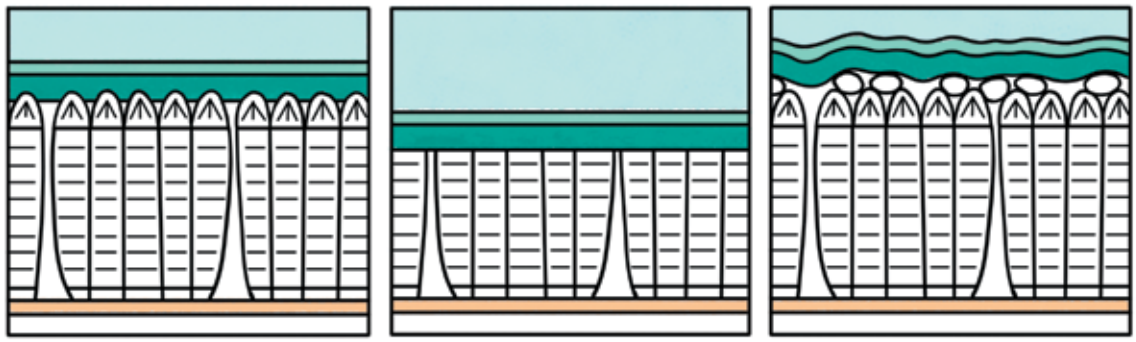
Types of thin shell

Not all thin shells have the same cause. The most common cause is age, i.e. shells from older hens are thinner than they are with a young flock. If that is not the reason, you should consider the following factors:

- are eggs from a breed that produces brown eggs the normal colour but they still have weaker shells? If so, it indicates a calcium deficiency.
- are brown egg layers laying white and weak-shelled eggs? In that case, the hens are laying the eggs too early.
- do the eggs with weak shells have flattened sides? If so, there were two eggs in the shell gland at the same time (a fault in the ovulation cycle).

Glassy-pointed eggs

Mycoplasma synoviae causes glassy-pointed eggs. Glassy-pointed eggs are brittle and break easily, and they often soil other eggs. These eggs usually appear when the flock is around 28 to 35 weeks old. A laying hen that produces glassy-pointed eggs (GPE) does so for the rest of her life. The animals do not look sick but there is a mycoplasma (MS) infection in the hen's oviduct, and treatments only have a temporary effect. Seeking out GPE eggs and cleaning soiled eggs only increases the poultry farmer's costs When hens are more than 65 weeks old, the number of GPE eggs reduces, because the hen stops laying or the eggs are so weak that they are eaten before being collected. Preventive vaccination can limit the damage.



On the left a normal egg shell. In case of a mycoplasma infection, the mammillary knob is absent or there are irregularities between the knobs and shell membranes, which hinders a good attachment.

The point of this egg is rougher and thinner than a normal one, and there is a clear definition between the healthy part and the glassy point. Candling makes it even more visible. The cause is a Mycoplasma synoviae infection in the reproductive organs. The same hen always lays these eggs. Treat the hen and these eggs disappear completely. But it is a waste of time, because the GPE eggs will be back about fourteen days later.

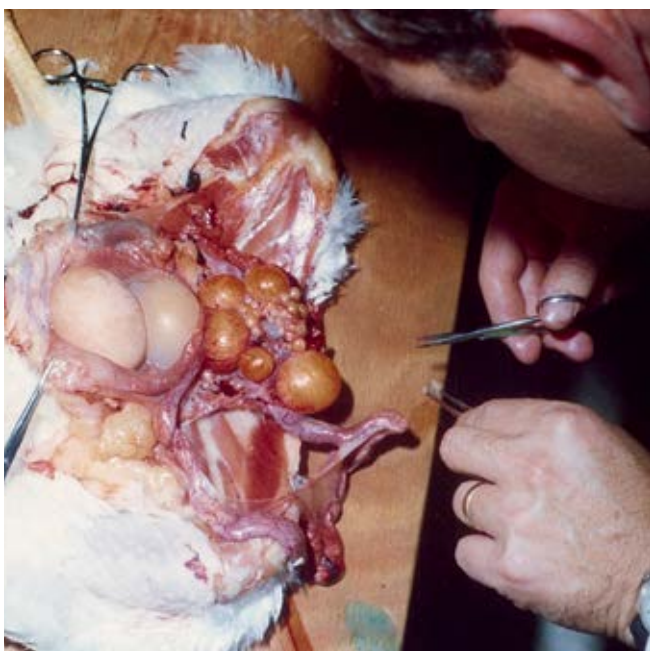
Dented eggs

Sometimes in young hens, one egg follows another too quickly. This shows up differently for each pair, e.g. an egg within an egg, a double yolker, a 'Siamese' egg in which two eggs grow together, or a dent in the egg.

With eggs with a flat side, the first egg has calcified rings, and the one with a flat or dented side is the second egg. Dented eggs occasionally occur among breeder parent hens and laying hens. The egg was already finished, but extra calcium is deposited because of the arrival of the second egg. This extra calcium layer is on top of the cuticle and is easily scraped off. Additional calcium deposition is always white and not brown, while the brown pigment is added at the end of the process. This egg is laid 28 hours after ovulation (4 hours late), so you'll find it back as a floor egg. The laying will not be in sync with the hen's behaviour.

The second, dented egg is laid at the normal time, the next day. The prevalence of dented eggs can be an inherited trait associated with ovulation frequency. Other causes include stock movement and disruption, excessive stocking density, or extending the lighting schedule too quickly when the hens start laying. The best advice is to ensure that your hens have peace and quiet, enough space, and an appropriate lighting schedule. Extending the dark period in the house can sometimes provide a solution (more rest). Poultry farmers are generally not keen on shortening day length, because they fear reduced production. In fact, a fourteen-hour day is not a problem.

If you pick up an egg with a dent and one with a calcium ring, you can see exactly how they bumped into each other in the reproductive organ.



Section of a hen with two eggs in the oviduct. Obviously the hen formed the second one to quickly after the first. Normally there is only one egg in the oviduct at a time.

An x-ray picture of two eggs in the oviduct. You can see a round contour of a second egg following the well-formed one.

Pimples and sandpaper shells (calcium deposits)

Eggshells should be nice and smooth. Any unevenness or irregularity is a clear signal that something is wrong with the individual hen or the whole flock. There are different types of rough egg shells: is it extra calcium deposit or just a bad shell? And the time shell formation occurred plays a role - you can scratch off late calcification, but not excessive amounts laid down originally.

Sandpaper shells

Shells that feel like sandpaper, rough, and uneven. The cause could be Infectious Bronchitis (IB). This causes oviduct tissue to slough off and if this dead tissue lands on the surface of the egg as the shell is forming, a pimple will occur. In case of IB the egg albumen will also be watery.

Typical sandpaper shells.

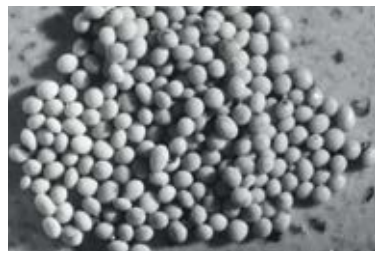
The sandpaper effect can also be limited to a part of the shell, and then it is only a rough place on the egg's tip.

There should never be more than one or two eggs in a tray of thirty that feels like sandpaper. Stroke the eggs in a tray with your hand and you will notice these types of eggs easily. A tray of eggs should not feel like you are reading braille!

Little pimples

Little pimples on eggs consist of a calciferous material on the eggshell. Pimples are caused by foreign substances in the oviduct being deposited onto the surface of the forming shell. The shell continues to form around these foreign substances. This phenomenon is connected with hen age, poor feed, or a genetic defect.

An egg with many little pimples on the side.



When magnified powerfully, they look as follows.

Large pimples

Larger pimples occur on eggs regularly. Sometimes you can break the pimples off easily and without any damage, but some leave pitting in the shell when removed. Breaking off large pimples can leave a hole in the shell, while usually leaving the shell membrane intact (right image).

A larger pimple on the eggshell, which you can easily break off.

The eggshell usually remains intact after you break them off (unlike with pinholes or implosions).

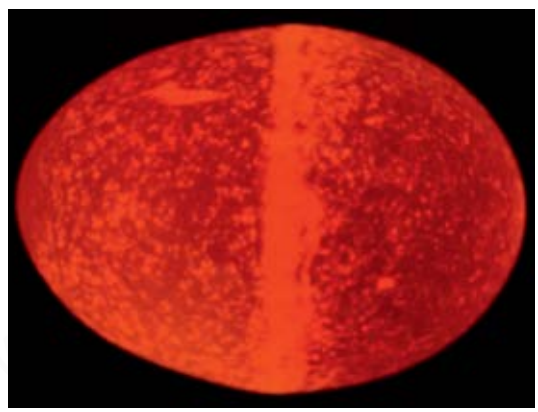
Repaired egg shells

A thick rib running around the middle of the shell, or at the point, is a sign that this eggshell has been damaged whilst it was forming but that it has subsequently been repaired. This type of damage is caused by stress or pressure being exerted on the forming eggshell through movements or disruptions. Causes of stress include anxiety or disruption during shell formation, in the last hours of the light period or the first half of the dark one. Make sure it is peaceful in the house during this critical time and avoid too much activity by dimming the lighting.

Turning on the lighting briefly at night for a short feed should also be avoided. Also avoid excessive stocking rates, especially mixing younger birds with older hens.

Repaired egg shells occur more often with increasing bird age, and can rise to as much as 9% when a flock reaches 60 weeks.

An egg with a bulge, showing a clear ring around its middle, where the shell was broken.



The same egg as it appears in front of a candling lamp.

An egg with old and new cracks intermingled – The damage could have occurred partially in the uterus, but this egg was laid normally.

You also see a ring around the middle of double yolkers. That ring is not as much a result of repaired damage, but rather the point where the two eggs were joined.

Other shell abnormalities

About 2% of total egg production will have shell abnormalities. With flocks older than 70 weeks, the rate can increase up to 10%. The eggshell should be smooth, shiny, and strong. Eggshells that are soft, dull, rough, ribbed, or misshaped are considered abnormal. Causes include the bird's condition at the onset of lay, disease, genetic faults, feed, stress, or disruption to the bird at critical times in the egg forming process. Know your birds and the underlying factors well, so that you can handle these problems effectively.

A weird shape like this could indicate ND.

An egg with this specific point could be a signal for ND. Despite ND vaccinations you still come across these egg types.

This egg was damaged during shell formation and repaired. However, the shape is still a bit odd.

Signals from shell abnormalities

You can divide the different signals you see on eggshells into the following groups of causes:

- shell abnormalities originating from the hen itself
- shell abnormalities originating before laying
- shell abnormalities originating during laying
- shell abnormalities originating during egg transport and collection
- shell abnormalities caused by disease
- shell abnormalities caused by other reasons

LOOK-THINK-ACT

What does this bump on the head mean?

This egg has a clear bump on its 'head'. It might be a signal of a Newcastle disease (ND) infection. ND causes misshaped eggs. It is good practice to vaccinate against this disease.

A ribbed point might be caused by stress. The egg remained too long in the last bit of the oviduct which caused additional calcification at the pointy side.

In this malformation the horizontal lines actually show the plies of the uterine wall.

A so-called 'granny egg'. A wrinkled egg, probably caused by IB.

Granny eggs or corrugated eggs appear in every shell colour. On photographs you see mainly brown eggs, because there they are most clearly visible.

Egg where the outer calcified layer with the pigment has come loose. Perhaps there is a normal egg underneath and the pigmentation process has restarted.

Are there more abnormalities in cage housing?

You can see a variety of signals on eggshells. There seems to be more shell defects in cage housing, but this is mainly because almost all the eggs laid get onto the egg belt. In free run systems, hens often lay abnormal eggs outside of the nest boxes, because the timing of laying is not synchronised with the hens laying behaviour (shell-less eggs = too early, and an extra calcium ring = too late). These eggs break immediately, or will be dumped or processed separately as floor eggs.

Calcium deposition

Normally calcium deposition is evenly spread over the egg. If that process is disrupted, you might see a variety of patterns of excessive or irregular calcium deposits.

A calcium ring indicates that the egg was too long in the reproductive system and a second egg collided with it. Thus, there is also a second egg with a dent.

A lilac egg. You often find one of these eggs as an exception among a batch of normal ones. An extra layer of calcium was deposited. i.e. after forming the cuticle. If you rub a wet finger over the eggshell, the true colour shows through (right egg).

An extra layer of calcium means that the egg was laid six to eight hours too late. You find that kind of egg in different locations around the house, wherever the hen concerned happens to be at the moment she lays it. When the next egg comes into the shell forming section, the hen gets a signal that the 'old' egg is still there. And she lays that egg immediately, without taking time to find a nest box (or it occurs when the nest box is closed).

The air chamber

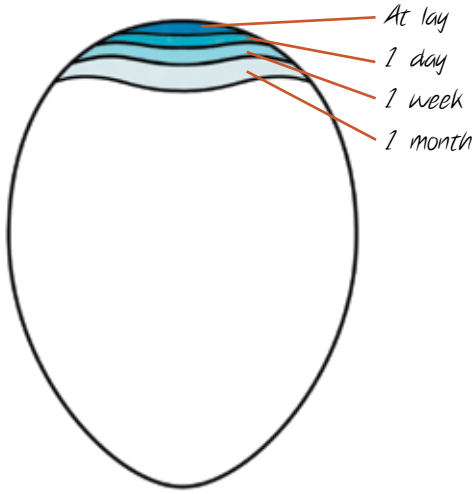
In a fertilised egg the air chamber, or air cell, provides the chick with air just before it hatches. The air chamber is at the blunt end of the egg, where there are the most pores. You can tell the age of a table egg by the size of the air chamber. Storage conditions have a big influence on the size of the air chamber of table eggs. If eggs arrive at the packing station within three days, they should have an air chamber of less than 2 mm.

Air chamber formation

The older the egg becomes, the bigger its air chamber. The air chamber is formed at the blunt end of the egg where the two shell membranes are easiest to separate. The air chamber forms when the egg is laid, because the environment is cooler than the hen's body temperature. The temperature difference causes the egg contents to contract (the shell itself cannot), which in turn sucks air inside and makes the inner and outer shell membranes separate at the blunt pole.

Quality classes and air chamber	
A	< 6 mm
B	6 - 9 mm

The size of the air chamber is one of the determining factors of egg quality.
The air chamber in an A grade egg must be less than 6 mm. With a fresh egg, it should be smaller than 4 mm.



The air chamber enlarges during storage. There is only a tiny air chamber at the time of laying, and it grows steadily over time.

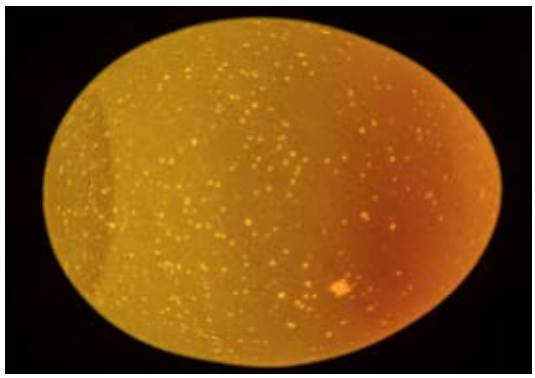
Measuring the air chamber

The air chamber format tells us something about egg quality. It is a quality characteristic. You can measure the air chamber with an air chamber meter. You use it by holding the egg in front of a lamp so that you can see the air chamber. Mark this position and subsequently you can read it, using the air chamber meter.

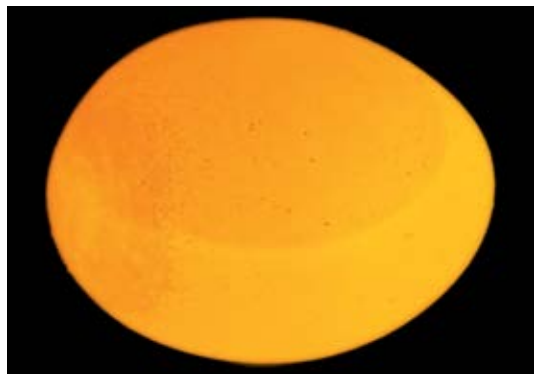
Loose air chamber

Sometimes the air chamber is not confined to the blunt end, but drifts loosely around the egg. For example it might be on the side, and it moves as you move the egg. We call this type of egg a 'rattler'. You can actually make an egg become a 'rattler' by shaking it very hard. You can check for this phenomenon easily. Put the egg in the candling position above a light box. Rotate it quickly. Then rotate it speedily in the other direction. If there is a loose air chamber, you will see it move. A fixed air chamber stays in place.
The cause of loose air chambers is essentially unknown.

In a broken egg you can often still see the air chamber at the blunt side of the egg.



Normal egg.



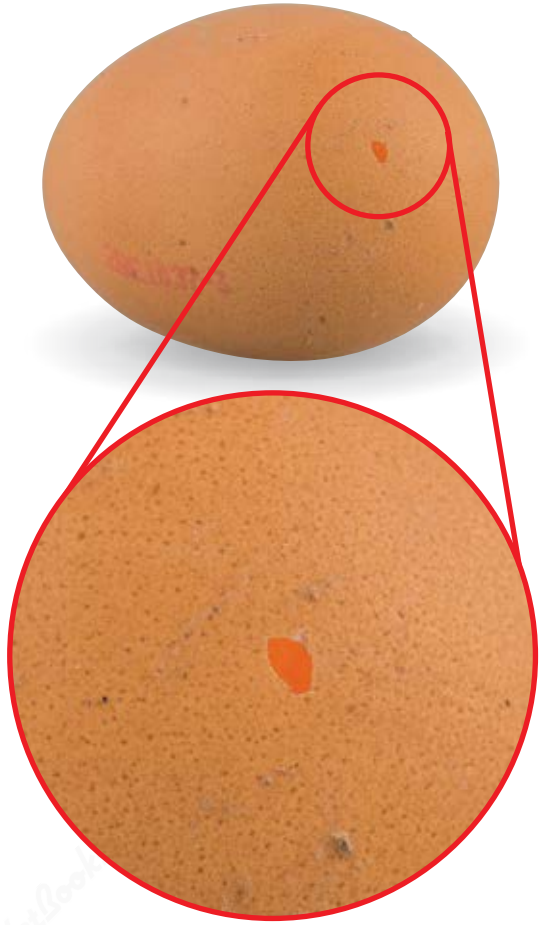
Air chamber at the side (rattler).

The position of the air chamber in a normal boiled egg.

The position of the air chamber in a boiled egg with a loose air chamber.

Holes

Sometimes you might see a hole in an eggshell, mostly a tiny hole. A hole usually represents eggshell damage caused from a protrusion somewhere on the equipment in the house or because of bird damage (beak or toe). The egg content contraction after laying sucks the weakened point on the eggshell inwards (implosion). With this type of damage you will see that a bit of shell is still attached to the shell membrane inside the hole. Make sure that there are no sharp components in the nest boxes or on the collection belts and make sure the birds cannot access their eggs once they are laid. A hole can also occur when eggshell pimples break off. But in that case, you will not see the little piece of shell inside the egg.



The hen can also make a hole in the eggshell by pricking it with her toenail or with her beak. You will recognise the shape of the nail or beak in the hole if it has been caused by the bird. Make sure that the nest box inclination allows the eggs to roll away.

A hole caused by a missing piece of the eggshell, but the shell membrane is still intact. This is possibly a point where a pimple has broken off.

This hole is more likely the result of an implosion. A week point on the eggshell has been sucked into the egg through cooling or drying out.

CHAPTER 7:

Egg laying

Housing systems are designed so that hens can lay their eggs without disturbance. Knowledge of natural chicken behaviour is essential for managing this well. The system design is also aimed at keeping the egg intact and transporting it away from the production unit properly.

There are many factors concerning egg laying that affect egg quality. Consider things like housing, climate, disease, and parasites.

Difference between strains

There are great differences in strains' laying behaviours. Some strains are more prone to laying floor eggs than others, because of different levels of urge to lay in a nest. There are even strains that prefer laying standing up, while others squat. The percentage of hens that lay their eggs blunt or pointy end first also varies between strains. This factor might be associated with breeding that leads to round or more oval shaped eggs, depending on the particular strain.

How a hen lays an egg

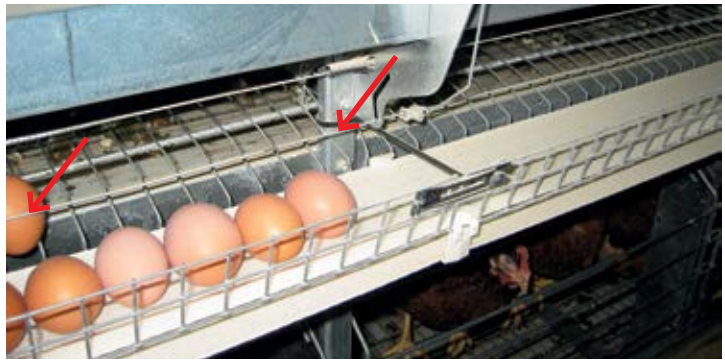
Hens are vulnerable during laying. Leave them in peace as much as possible while they lay their egg. Do not inspect nests during that time, avoid running the egg belts, and do not top up the feed during this sensitive period.

Cracked eggs and hairline cracks could occur if hens are startled during laying. Wild birds getting into the house, aircraft passing over, or electrical current on metal parts of the housing system (leakage of electricity) can startle the hens. The lighting schedule in the house has an influence on laying behaviour. You can use light to control peaks when many hens want to lay at the same time. The lighting schedule can also influence the occurrence of egg abnormalities. For example, if there is too much light or the birds are active during the evening or night because you are using an intermittent lighting programme it can result in 'body-checked' eggs (internal lay).

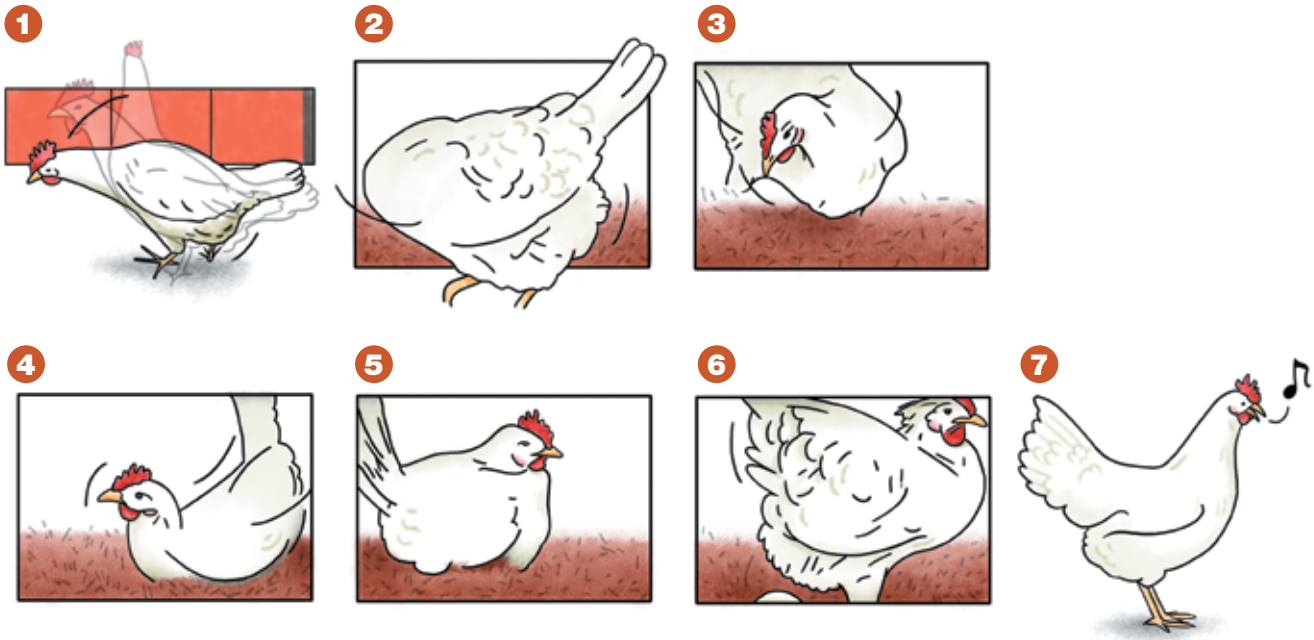
Influences on dents and fractures

The following parts of housing equipment have an effect on the incidence of dented or fractured eggs:

- the depth of the nest box (how far the eggs must roll – the deeper the nest, the greater number of hairline cracks)
- floor construction (the materials it is made of, thickness of the rods, and the inclination)
- obstacles the egg encounters (vertical profiles or egg savers)
- the nest box (the nest box floor, height differences, and transfer to the egg belt)



You can use an egg saver to ensure that the eggs do not bump into each other on the egg belt. An egg saver is a steel wire like device, which retains the egg and rises to release it every so many minutes. This ensures the egg arrives whole but also dry, which in turn prevents dust and dirt on the belt sticking to it so easily.



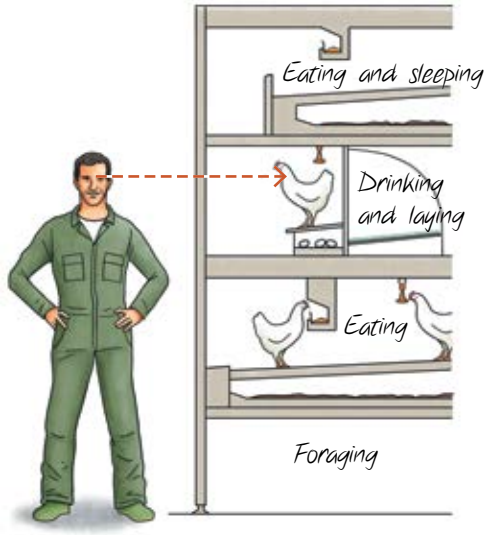
1. *The hen looks for a nest. The hen sits, relaxed, for a half hour, sometimes with her eyes closed. Then the hen becomes more restless.*
2. *She lifts her tail regularly, and raises the feathers around her cloaca.*
3. *The hen stands up a bit suddenly, and spreads her legs.*
4. *The hen pushes several times in sequence, and the egg comes steadily further out.*
5. *The damp egg comes out, followed by a red protrusion. After a few seconds, the protrusion is retracted, and the cloaca closes.*
6. *The hen stands tall on her feet, above her egg, to rest. She keeps her beak open and gasps air for a moment.*
7. *Then she inspects her egg and leaves the nest, sometimes but not always with a loud cackle. She eats and drinks a little and then continues her daily routine.*

Good house design = fast inspections

You need a well thought out house design and installation to allow you to carry out quick and easy inspections of your hens. Often, the birds are housed in compartments with a maximum of 6,000 hens (in organic systems, maximum 3,000 per compartment). The layout of the housing system must also suit the chicken's natural laying behaviour. In most houses, all the nest boxes are on one level, at eye height. That makes checking them easy, and it is nice for the hens.

Birds tend to crowd together in corners or look for space to lay here when there is no room elsewhere. Overcrowding in corners can result in hens being crushed and suffocating, as you can see here. Electric wire was strung to keep hens out of the corner. However, animal welfare regulations no longer permit electric fencing in poultry houses.

Each level its own function



Mount a drinking water line in front of the nest boxes. That will help to entice the hens there. By mounting the drinking nipples on a similar place during rearing, you train the hens and they will quickly find a peaceful place at arrival in the laying house.

LOOK-THINK-ACT

Why are the upper laying nests cramped with hens?

In systems with laying nest on various levels, you often see that the upper nests are used most frequently. That happens because hens prefer higher nest boxes by nature. It is a normal phenomenon, and you should keep that in mind regarding the frequency of running the egg belt. The upper egg belt determines the moment of egg collection, but is often not the easiest to check. Be aware of that. Besides the total number of eggs, distribution within the system plays a role in timing of egg collection.

Nest occupancy

A hen always needs some time to lay her egg in peace. Make sure that they are distributed well between the nest boxes, and prevent overcrowding. Make sure that the hens can walk around easily, and that there are no dead-ends created by a wall or suchlike. Houses with nest boxes fitted close to a wall have many more problems with crushed hens and hairline cracks in eggs.

Currently, group nest boxes with a capacity for about 120 hens per m² are the most used version. Sometimes, there are 25-30 hens laying their eggs at the same time in a nest box measuring 100 x 30 cm. Over occupation will result in more mortality through crushed hens, and soiled or broken eggs.

LOOK-THINK-ACT

Why is this egg in front of the nest box?

There are several eggs in front of this nest box. Nest boxes are often closed between 15:00 and sunrise to prevent the birds from soiling them. If the nest stays closed too long in the morning, some hens will lay their eggs in front of the door. If you often see that happening, open the nest boxes a bit earlier.

Eggs drying out

Hens lay eggs wet but they dry very quickly. The high temperature of the egg, when laid, dries it out in a couple of minutes. But it is much more sensitive to damage and fouling while still wet.

A wet egg, immediately after laying.

The egg 5 seconds later – you can already see it drying.

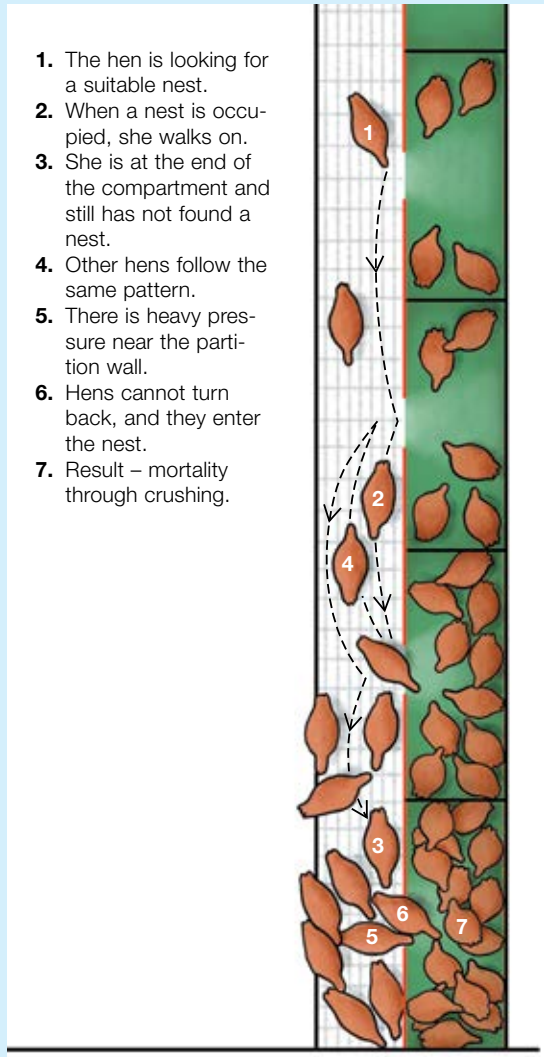
The egg 10 seconds later – it is now almost dry.

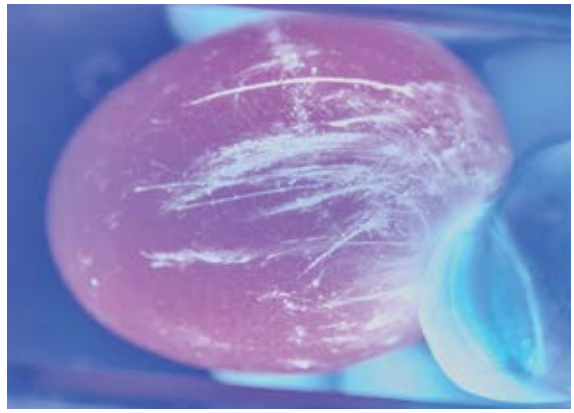
Risky locations are primarily the nests at the end of a row

You find the most crushed hens in the nest boxes at the end of rows, next to partition walls between compartments. The reason is as follows. The hen needs to lay an egg and searches for a suitable spot. She walks past occupied nests and finally arrives at a dead end, where she remains, walking backwards and forwards until she finally has to lay her egg.
This happens to a number of hens, which is why the nests at the end of rows have the highest occupancy. These nests need extra attention during daily inspections. Make sure there are enough nest boxes. Make sure that hens can circulate, by not placing any nest boxes against walls or partitions, and thus avoid any dead ends.

This hen was crushed to death in the nest box, because of excessive nest box occupancy. This occurs mainly at peak production when there is little distribution of laying times. Make sure that there are enough nests.

1. The hen is looking for a suitable nest.
2. When a nest is occupied, she walks on.
3. She is at the end of the compartment and still has not found a nest.
4. Other hens follow the same pattern.
5. There is heavy pressure near the partition wall.
6. Hens cannot turn back, and they enter the nest.
7. Result – mortality through crushing.

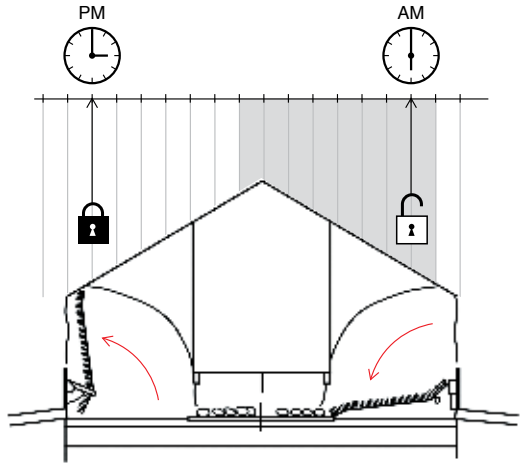




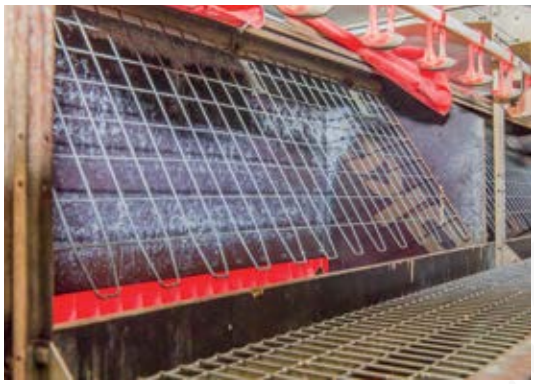
The risk of hens scratching eggs with their feet is greater with excessive stocking density, but also when the eggs do not roll away well. You can see the scratches even more clearly under a UV lamp. On brown eggs these scratches are more visible than on white eggs.

Nest boxes are exclusively for laying eggs

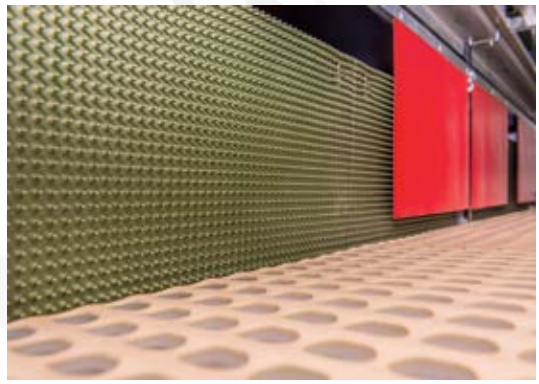
Make sure that nest boxes are only used for laying eggs in the morning. Otherwise, the hens will go into them to hide, rest, and leave their droppings. This will cause unnecessary high numbers of soiled eggs coming from that nest. You can close off the nest boxes at 15:00 and open them again one hour before the light goes on.



All the hens are driven out of the nest boxes at 15:00. Most hens have laid their egg a long time before. If you have a problem with too many hens still in the nests, close them one hour earlier.



A drift fence drives the hen out of a nest box in two minutes, but the hen can become easily trapped. The floor also remains horizontal, which means that dirt stays on it. Dirty floors increase the risk of soiled eggs and unhygienic conditions.



Usually nowadays, bottom lifters are used – the nest bed tilts toward the vertical position, while the flaps are rolled up in front of the nest. The advantage is that dirt falls off the mats and the hens peck them clean.
Clean nests mean clean eggs, and a hygienic environment for the hens.

The nest box floor must return properly to its position after lowering (left), so that the egg can roll smoothly onto the egg belt. Sometimes, with older and dirty lifters, floors do not return properly to their position (right), which leads to a gap between the nest and egg belt, which the egg falls over. This increases the risk of damaged eggs. Check operation and look for dirt build-up regularly.

Egg shell cleanliness

The cleanliness of the eggs tells you a lot about hen health in the flock, and the feed composition and/or housing. The causes of dirty shells include droppings, urine, blood, dust, wet litter, spilled egg contents, red mite, moulds, or fly droppings. There are various possible factors that lead to these types of soiling:

- **The hen** – Gastrointestinal disorders can give the hen thin watery droppings, which will soil the eggshell. An incorrect feed composition can also cause the problem. Contact your feed supplier or vet. Feeding during laying time is another cause, because hens defecate shortly after feeding.
- **Behaviour** – Feather-pecked hens that are low in the pecking order might be sheltering in the nests and leaving droppings, thus causing soiled eggs.
- **The system** – If the system for driving hens out of the nest boxes does not function properly or they close too late, dirty floors can make eggs dirty. Wear and tear on the nest box floor is another possible cause.
- **The environment** – Wet litter causes dirty feet, which in turn lead to soiled eggs. Even a plank in front of the nest box can be a source of dirt carried into it.
- **Feed management** – Ensure that the feed run schedule prevents the highest manure production from coinciding with the time when most hens lay their eggs.

There is a connection between dirty eggshells and hen age. Older hens produce larger eggs with thinner shells that result in more damaged ones, which then cause more soiled eggs. In addition, older hens are more prone to gastrointestinal problems. The nest boxes are also dirtier at the end of the production period and there are more floor eggs.

This egg has manure, in long stripes along its length. The hen has a gastrointestinal problem. Check hen health and the ration in collaboration with your consultant/vet. If this occurs more often, arrange effective medication against gastrointestinal disorders and check whether the hens were properly vaccinated during rearing.

This egg is soiled with spots of manure. The hen has defecated on the egg after laying it. The manure on it is caecal manure. The egg did not roll away quickly enough. If this occurs often, check the inclination of the nest floor, and for wear and tear or contamination on the mats. Make sure that the feed runs are scheduled in a way that avoids hens defecating at laying time. Often, the birds defecate just after they eat.

This egg is smeared all over with manure. It happened during egg transport in the house. It could be a case of manure getting onto the egg belt.

Pee-spots on the egg.

There are strange stains on this egg. These stains consists of uric acid and urates, which you normally find on the surface of droppings. Uric acid and urates are a sort of urine. The cause can be kidney failures or gout, which can occur among older hens.

Tiny specks of blood on eggshells indicate a heavy red mite infestation. The specks are squashed red mite, caused by the egg rolling on the egg belt while it was covered in them. This egg is actually covered with live mites.

LOOK-THINK-ACT

Why is there blood on this egg?

There is blood on this egg. This occurs mainly among young hens, when the vagina/cloaca still needs stretching. Make sure that young hens do not get too fat, because the cloaca will have to stretch even more when laying an egg. This can lead to cloaca damage. A sudden extension of the lighting period at the time the hens start laying can also cause blood on the eggs. Blood on eggs can also result from laying very large eggs (double yolk) or cloaca pecking. Sometimes, a protruded cloaca is an invitation for other hens to peck it.

Dirty eggshells caused by housing

In a nest box, the egg rolls away from the bird to the rear. The inclination of the nest floor and mat cleanliness are the main determinants of egg cleanliness. The nest box flooring material must not be worn or damaged.

With a worn floor, eggs can remain longer, stuck in a pit. That is why you see more stripes and imprints on the egg.

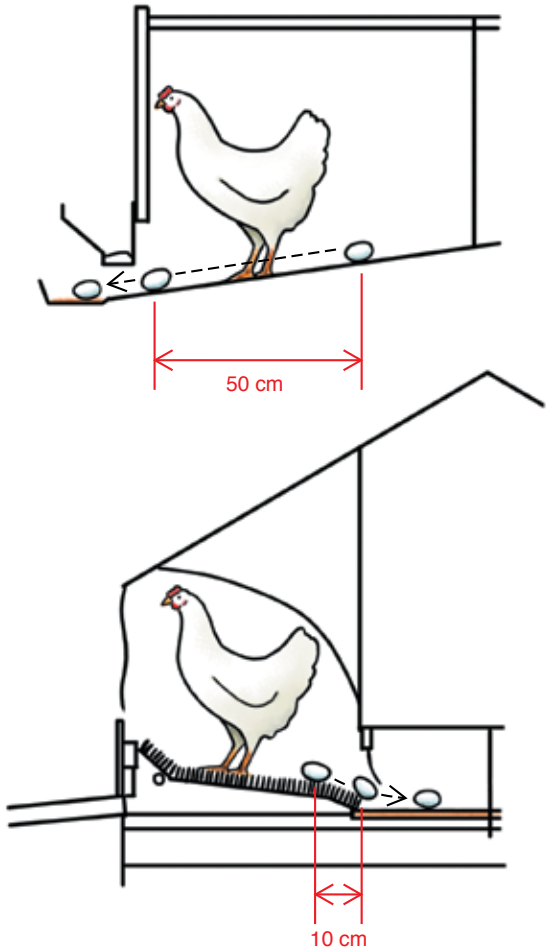
An egg laid in a traditional cage, rolls over the rods, between the hen's legs toward the front and onto the egg belt. So, soiling can also occur in the cage. If the egg is not fully dry, dust and dirt will also easily stick to it.

Dirty eggshells occur often in lower percentages in aviary housing than in cage housing. In cage housing you find about 4% dirty eggs at 60 weeks, in aviary systems this is only 1%, plus 1-2% floor eggs.

The little black points are fly droppings. They do not occur when management is good: regularly remove manure, use UV flytraps in storage rooms and fit fly screens. Store the eggs in a cool space.

In the United States, big egg production units often had deep cages. The fact that the eggs must travel further to reach the egg belt, increases the risk of dirty eggshells. Modern cages are shallower.

This is an enriched cage. An enriched cage is a cross between caged housing and an aviary system. The laying section is only partitioned with a curtain. The eggs also remain cleaner because of the curtain.

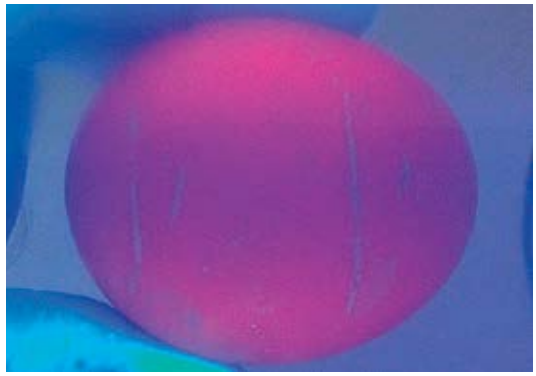


A hen lays her egg at the rear of a conventional cage. It then has to roll to the front between her legs and the legs of other hens. That means more contact with her legs and a higher risk of dirty eggs. In a nest box, the egg rolls directly to the rear of the nest box thus reducing the risk of soiling.

Rollaway stripes/cage marks

When the eggs roll away over the metal floor of a cage to the egg belt, you can find rollaway stripes. This occurs when the cage floor is dirty, worn, or corroded. Dust sticks on the still-warm cuticle (irremovable). The stripes are spaced at the same distance as the rods in the cage. The warm, moist newly-laid egg is very sensitive to damage of its pigment layer. Clean the rods, galvanise the rods again, or replace the flooring.

In countries where egg stamping or printing is not obligatory, some producers might try to sell eggs from caged hens as aviary products. A quick check for rollaway stripes will reveal the true source. So this is a good check to prevent cheating!



If you cannot see rollaway stripes with the naked eye, it is often more visible under a uv-light. On white eggs this is useful, since on white they are hardly visible.

On brown eggs where the pigment is close to the shell surface, the rollaway stripes are often very visible.

On eggs from a dirty nest you will see more short stripes/spots than large patches of soiling. You can actually recognise the structure of the mats in it. This is worse if the eggs are not yet dry before rolling to the egg belt. Make sure you have high quality nest floors, effective hygiene, and a well-ventilated house.

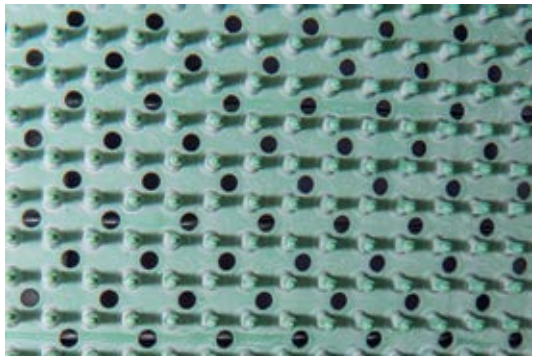
LOOK-THINK-ACT

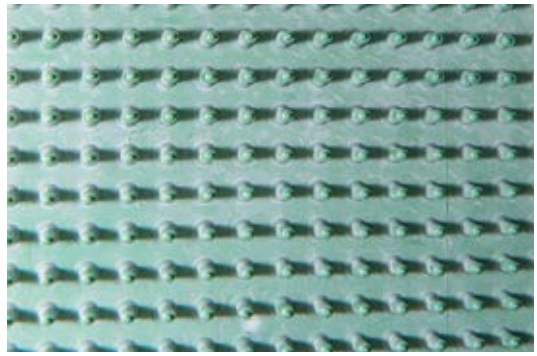
What are these stripes?

On this egg you see stripes. However, these are not rollaway stripes (where the pigment layer is damaged), but dust stripes by the jute egg belt behind the laying nest. These dust stripes are on the egg and can be wiped clean.

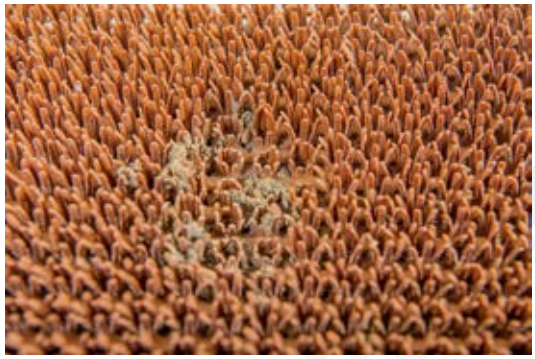
Dirty eggshells in the nest box

The 'fingers' on the nest box mats minimise contact between the egg and dirt or droppings. The shape of these little pins ensures that the eggs can roll gently to the egg belt. The mat also provides comfort for the hen.

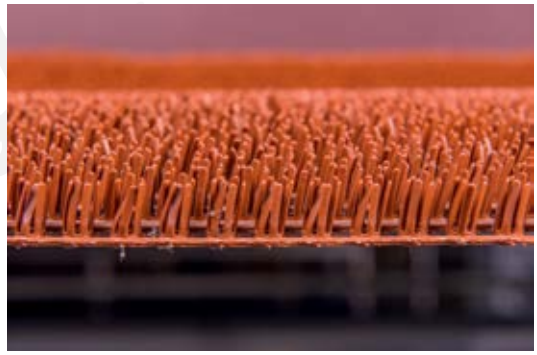




There are many types of nest box mats. The choice depends on many factors. On the left a mat that has holes, which makes it better suited for warm climates.



A worn mat collects dirt, which stops the egg rolling away and increases the risk of footprints on the eggs. Replace the mats before they are worn, around once every five years.



Nest box mats have an open structure, which prevents dirt and dust building up. They contain short and stiff pins or long thin ones. Each type has advantages and disadvantages, but long, thin plastic pins can bend down under a sitting hen, causing feathers to stick in them.

LOOK-THINK-ACT

Why are there stripes on this egg?

These are foot prints of hens. It can be a signal that the mats are old and worn; the egg cannot roll away fast enough. Check the plank in front of the nest, it might be dirty. A hen that steps on a dirty plank will pick up dirt and take it into the nest box.

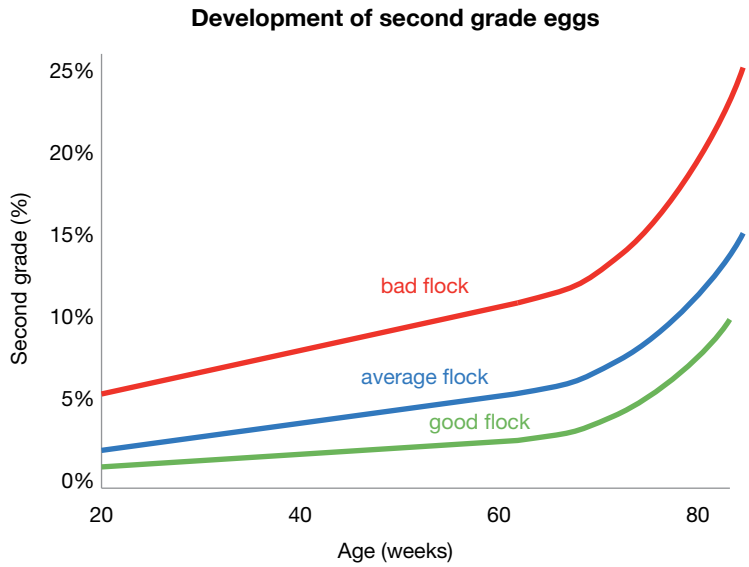
Development of shell fouling

Shell dirt and therefore second grade eggs increase during the laying period. There is a great difference between flocks and their management. The poultry farmer cannot keep track of more than 10% of the eggs when inspecting visually. He then has to have more people inspecting or he has to run the belt more slowly, or stop it more frequently.

Shell dirt arises especially from:

- Dust
- Droppings
- Pitch
- Yolk
- Egg-white

Also, blood, wet litter, mites, fungi, and fly droppings can produce shell dirt. A feather is not perceived as shell dirt and an occasional feather on the egg is no problem. But automatic detection equipment does see feathers as dirt, so the egg in question is (wrongly) classified as second grade.



With a bad flock, shell dirt rises quickly beyond 10%, making visual detection above that difficult for one person.

Some eggs are so dirty that they are not even suitable as second grade eggs. There is a large risk of manure crossing the shell into the end product, which is, of course, not permitted. Also, if there is an open fracture in the shell, the suction device will empty the egg when trying to lift it.

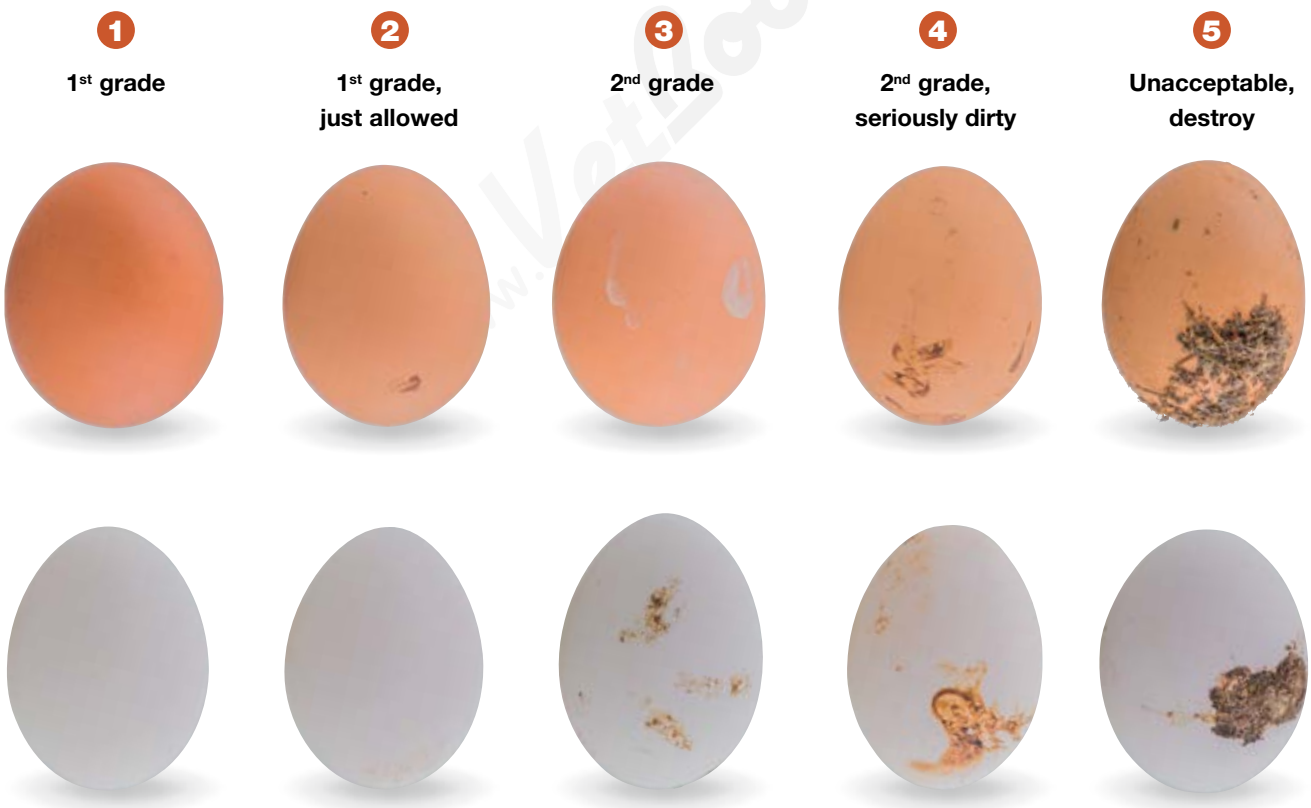
White and brown egg with fungus stains. The danger of fungi is that they can also quickly contaminate other eggs.

Eggs with spilled content on the shell (egg white or yolk) always get a second grade stamp, in consideration of food safety. The shell contamination does not generally come out of the egg itself, but occurs during transport, e.g. spillage from a broken egg in the tray above. Egg yolk is easy to recognise. Egg white often shows as a shiny layer or simply a dirty area that dust sticks to on the shell.

Assessing shell dirt

Eggs with dirty shells are not directly delivered to consumers, but are processed as second grade eggs. There are, of course, various degrees of shell dirt: from beautifully clean to very dirty indeed. The assessment is not constant throughout the entire laying period. At the start, eggs are strong clean, and the occasional speck of dirt is not a problem. The selection is then less stringent. Towards the end of the period, egg quality degenerates across the board. If you have a box with suboptimal eggs (gray, dull), then the extra egg with a dirty shell will not be tolerated. A stricter selection of second grade eggs results. Because the percentage of second grade eggs increases during the laying period, the numbers "missed" by the poultry farmer will also increase. Suppose that at the start 2% of the eggs are screened out, at that point perhaps 1% slips through. This is still acceptable if the remaining eggs are good.

But if 15% are screened out towards the end, and 10% of the total slip through as second grade eggs and that is too many. That is therefore an extra reason for being more stringent towards the end of the laying period. The stricter assessment of second grade eggs as the laying period progresses does not only apply to visual detection, but also translates to the limiting values programmed into the detection equipment. Shell dirt is tolerated more at the beginning of the laying period than towards the end.



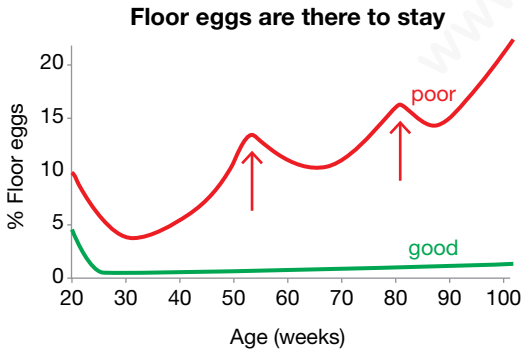
Floor eggs

You cannot sell floor eggs as first grade eggs, so the return is lower. Dirty eggshells are not the only reason; the high percentage of floor eggs with hairline cracks is another factor. As soon as the hens start to lay, you need to do everything you can to prevent floor eggs. It is not only a question of the timing of opening the nest boxes, it is also important to remove any floor eggs as quickly as possible as this will prevent other hens laying theirs next to them. If you remove floor eggs as quickly as possible, the hens laying floor eggs will be more prone to mimic the behaviour of the ones that lay in the nest boxes. Prevention is better than cure.

A rule of thumb – begin training the pullets before they start laying. Let them sleep in the system, and make sure that they learn to move around in it, because that is often the actual problem.

Collecting floor eggs means extra labour costs, and they can be frustrating. In addition, returns are lower, because floor eggs are designated as second grade and you will also lose a portion of them through trampling or pecking.

Sometimes, it may seem that there are less floor eggs at the end of a cycle. This may be just an illusion, because the hens will eat more of them as the shells get weaker. Hens which develop an egg eating habit will come back for more. Empty eggshells in the litter are the signal.



You can reduce the percentage of floor eggs from 5% down to 2%. The earlier you take action, the better. Otherwise, there is high probability of the hens developing bad habits. Remember – chickens can learn a lot, but can unlearn very little! Unfortunately, you always have some birds that obstinately keep on laying on the floor. If you do not manage this well, peak periods will occur. Remove the litter during those peak periods (see the arrows on the chart).

Floor eggs are an invitation for other hens to lay their eggs next to them. That is why you should collect floor eggs regularly. At the start of lay collect eight times a day, with six of these being in the morning. After ten weeks, you should still be collecting three times per day, with two collections in the morning. It is normal to find 1-2% floor eggs.

Risk factors for floor eggs

Not enough training to move between levels
If the hens have not learned to move between different heights during rearing, they will not move between levels in an aviary system, and will not go to the level where the nest boxes are located during lay. Thus, it is best that the housing systems in the rearing and laying units are as similar as possible.

Shady spots
If there are spots in the house that are dark or in a shadow, increase the light intensity or provide supplementary lighting. It is also useful to incorporate a dimming phase at the start of the day. Some laying hens feel a need to lay their egg before the light goes on. Those eggs land on the grids, often very close to the nest box.

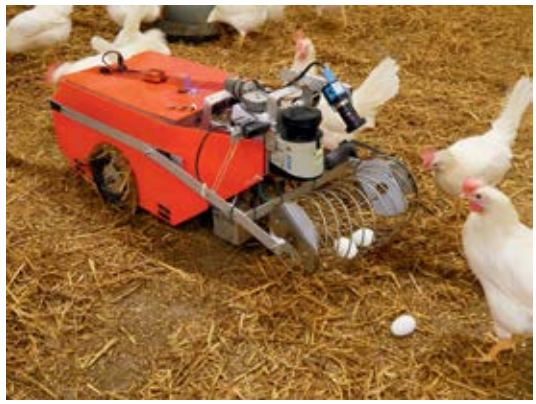
Nest boxes that are difficult to access
Birds have difficulty passing each other when looking for a nest. Resting hens can block the nest box entrances. Install more perches or a grill in front of the nest boxes so that the hens are able to pass each other and see which nests are occupied.

Attractive litter
A thick layer of litter is good for hens, but it also invites them to lay there. Prevent laying in the litter by using sufficient illumination and collecting any eggs there as quickly as possible. Disturb hens if they are laying floor eggs. Carry out multiple inspection rounds early in the morning with young flocks at start of lay.

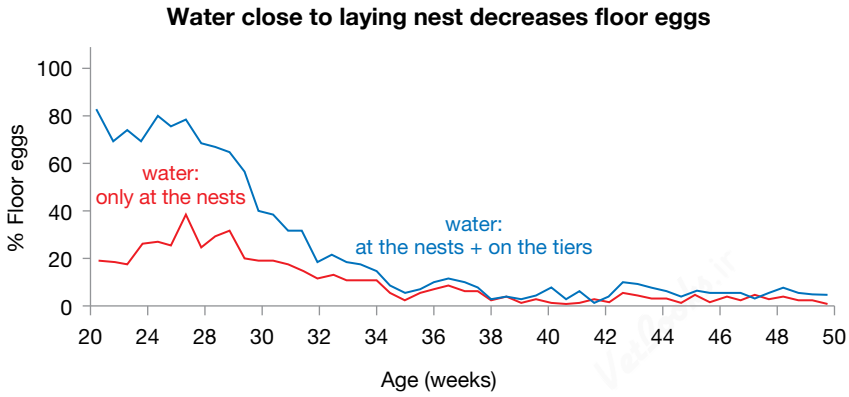
Draught in the nest boxes
You can check if there is a draught in the nest box by wetting a hand and holding it in there. If the space under the nest is cold, negative pressure can cause a draught. Hens do not like draughty conditions so they will go elsewhere. You can solve this problem with an airtight plate under the nest boxes. Incoming airflow is another possible cause of draughts.

No water in front of the nest box
If there is no water available in front of the nest, the hens will be less attracted to them, and might lay their eggs elsewhere. Check regularly that the water supply is working as it should.

This can be the result if a young flock has no litter. Very many extremely dirty floor eggs.



The PoultryBot can navigate autonomously around the house to collect floor eggs. The Farm Technology Group of Wageningen University developed this machine.



If hens can only get water near the nests, it reduces the risk of floor eggs.

LOOK-THINK-ACT

Why is this abnormal egg on the house floor?

This egg has an extra calcium deposit around its shell. The hen laying the egg six to eight hours too late is the cause. You often find this sort of egg on the floor or on the grids. A hen will lay this type of egg anywhere she happens to be at the time. The cause is that the ovulation determines the timing of laying behaviour, which includes sitting in a nest. If the egg stays too long in the oviduct for one reason or another, the hen lays it without any normal laying behaviour. Peace in the house at laying time is very important.

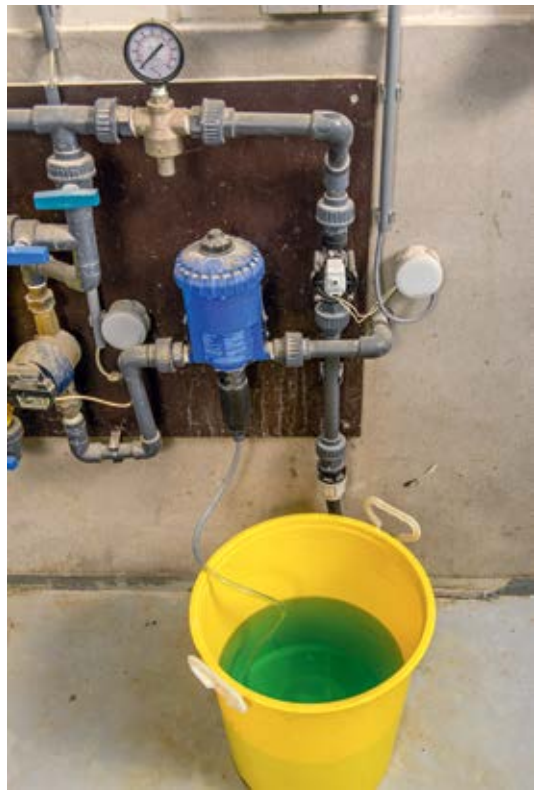
Salmonella – preventing infections

In many countries there are strict regulations regarding *Salmonella Enteritidis* (SE). Vaccination of laying hens is often mandatory. But the farmer should also take measures to minmise the risk of infection.

Salmonella infections in hens usually originate from picking up infected materials (dirt, dust, manure, and feed), which then cause a gastrointestinal tract infection. Salmonella can get into the poultry house through many routes, but the most important infection sources are the following:

- people (manure or dust particles, on clothes, under shoes, in the hair, etc.)
- pests (mice, cats, dogs, darkling beetles)
- feed
- farm equipment and materials that are not cleaned and disinfected, e.g. tools, egg trays, crates, and containers

Most types of salmonella infection only occur in the bird's intestines (caeca) and are shed in the droppings. *Salmonella Enteritidis* (SE) however can penetrate the intestinal wall and go further into the body, infecting internal organs and the ovary or oviduct, from where the bacteria can get directly into the egg yolk. If a laying hen is infected, the infection can therefore get into the egg contents before the shell is formed.



You can prevent the risk of salmonella by vaccinating the hens. This is a standard requirement for quality certification in many countries. Vaccination is mainly administered through the drinking water, at three times during rearing with live vaccine.

Infected manure in or around the cloaca at the time of lay can be another cause of an egg becoming contaminated with salmonella. Alternatively, eggs can become contaminated by coming into contact with infected manure in the nest box or in the litter. A freshly laid egg cools down causing its contents to contract. Salmonella on the surface of the shell can potentially enter the egg contents via the gas pores through suction as the egg cools.

Taking manure samples

In the case of caged flocks, you take two 150-gram mixed samples of droppings from all manure belts or scrapers in the house after each run. You sample all the different sections in the house.

In floor housing systems (aviary or free range) you can take manure samples using overshoes. In the EU, you have to take samples once every fifteen weeks.

1. Dampen the surfaces of the overshoes, using freshly washed hands. The overshoes should be made of an absorbent material.

2. When in the house, put the overshoes over your normal ones.

3. Walk around covering the entire area of the house. You should include the litter and the grids, as long as you can safely walk on the latter.

4. Do it twice in each house, to ensure a representative picture.

5. When you are ready to leave the house, put the overshoes in a sterile plastic bag. Send the sample to a recognised laboratory, by the next day at the latest.

Taking blood samples

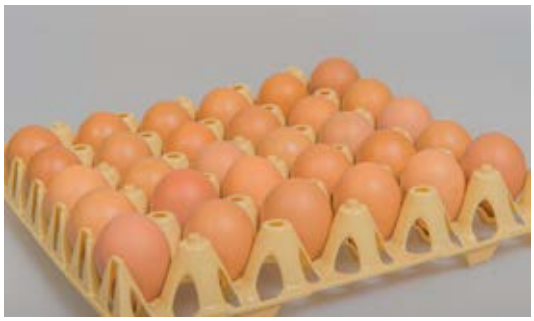
A test on blood samples from the hens can identify the presence of any antibodies against salmonella. This only works with non-vaccinated animals. Antibodies are only present when the salmonella bacteria have had sufficient contact with the hen's immune system to trigger an immune response. A positive result means that salmonella bacteria must have penetrated the intestinal wall, and that the primary infection will have occurred at least ten days previously.

CHAPTER 8:

Transport and handling

Everything that happens to the egg after laying requires the utmost care. The journey to the consumer begins right from the moment the egg leaves the nest box. You must select out abnormal eggs, and separate the others into their class. Any handling, e.g. stamping/printing, and, in some countries, washing are all part of the process. The delicate eggs have to survive all this handling without breakages.

It is reasonably easy to deliver good eggs with clean shells if you have good internal belt nest boxes with floor lifters.



Eggs that do not go directly to the consumer are often sent to a packing station. Transport might be in pulp trays, but plastic ones are becoming increasingly common. Plastic trays can be re-used (as long as they are cleaned well).

In-line and off-line systems

The route the egg takes after it is laid varies by country. The system can be in-line or off-line. In-line means that the eggs are already packed for consumers on the farm itself.
The use of in-line or off-line depends greatly on the size of the production farms and the supply chain structure in the country. The off-line system is used in countries with relatively small production units and packing stations.

Mixing age groups

With an off-line system there is a collection station where eggs from different sources are gathered. The advantage is that you can deliver eggs in all weight classes by combining eggs originating from hens in different age group, while with an in-line system there is often only one age group, and you can only partially cover four weight classes. Large scale farms in the US often have multiple age groups (6 to 12), and that allows one farm to cover all of the laying cycle.

This packing station adheres to very clear methodology. The day of receipt shows on a big board. The country of origin and husbandry system shows on a smaller board, and the green one carries delivery data.

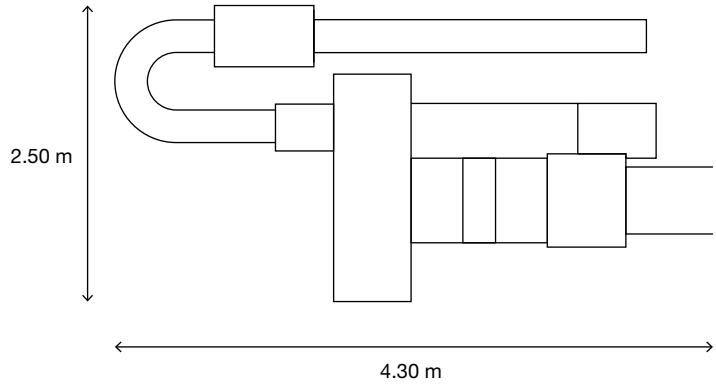
Difference between in-line and off-line systems

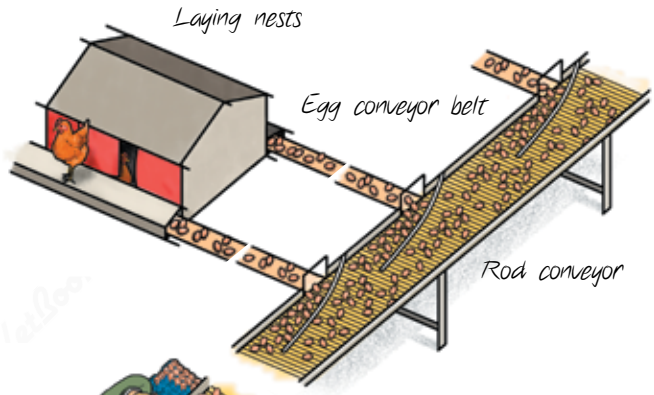
In-line	Off-line
Laying nest or area	Laying nest or area
Eggs collected on conveyor belt	Eggs collected on conveyor belt
Possibly egg elevator	Possibly egg elevator
Rod conveyor	Rod conveyor
Collection table	Collection table
Quality control	Quality control (manual pre-candling)
	Eggs turned also that all point in one direction
	Eggs put into trays
	Printing
	Packing of trays
	Tray stacking
	Loading of tray stacks on pallets
	Storage and transport
	Unloading and weighing pallet
	Removal of trays from stacks
	Removal of eggs from trays (placement)
Dirty or leaky egg detection	Dirty or leaky egg detection
Eggs turned so that they all point in one direction	Eggs turned so that they all point in one direction
Crack detection (hairline or other cracks)	Crack detection (hairline or other cracks)
Weighing	Weighing
Blood detection	Blood detection
Printing	
Sorting by colour (only for premium eggs)	Sorting by colour (only for premium eggs)
Eggs packed in retail packaging	Eggs packed in retail packaging
Boxing of egg packages	Boxing of egg packages

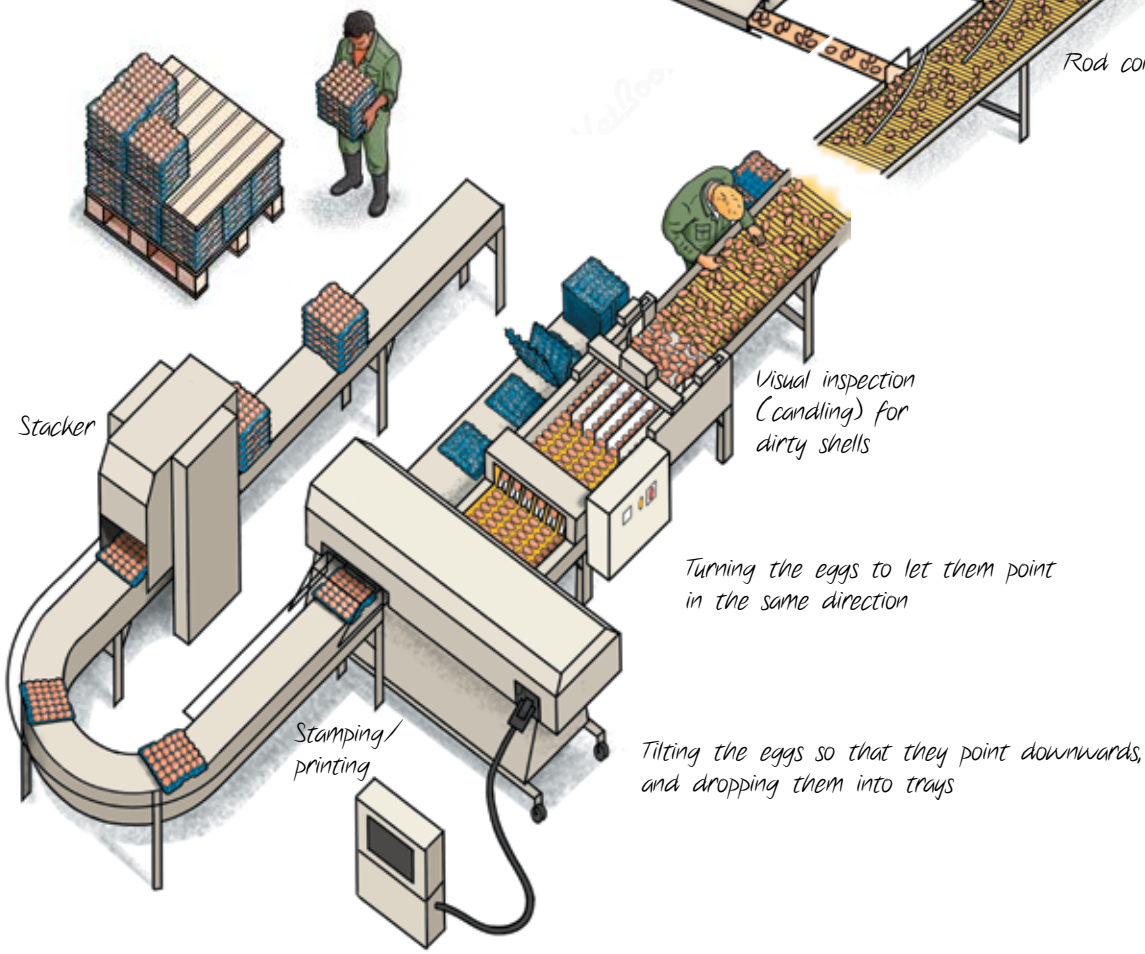
Farm-packer

A farm-packer can process 20,000 to 25,000 eggs per hour. The system puts the eggs into trays and stamps them, before they are stacked on pallets for transport to the packing station.

Badly positioned eggs in a tray will break more easily and you not only have a loss of return on that egg, but some other eggs in the tray may also become contaminated with its contents. In addition, the tray will eventually smell of rotten eggs.







Egg belt

The eggs roll onto the egg collection belt directly from the nest box. The belt transports the eggs to the central collection point. To ensure that the eggs lose as little quality as possible, transit points must be smooth, and you must keep the belt very clean. Calculation of belt capacity must provide plenty of leeway for the number of eggs transported. The more eggs there are on the belt, the greater the number of breaks or hairline cracks you will get. When the production rate is high, the egg belts must be wider, because running them faster will only increase the risk of damage.

Egg belt width

Selective breeding aims to stabilise egg size throughout the laying cycle, but in general, the eggs get steadily larger as the hens get older. Older systems were designed to handle smaller eggs than we now see, and thus they often cannot handle the modern production volume, because they are too narrow. Running belts more frequently is one possible solution.

Suppose that the design basis of an egg belt is a peak period with 93% laying percentage and an average egg weight of 60 grams. With good layers, the egg weight might increase to 65 grams with the laying percentage at 95%, which will then make the egg belt capacity insufficient at that point in the production cycle.

The nest boxes are usually all on one level in aviary systems, which makes egg collection easy. In cage systems, egg transport runs from multiple levels to the central collection point. Sometimes egg elevators handle the vertical transport between the different levels. In other cases, flexible egg carriers move the eggs through height changes on their way to the central collection point.

LOOK-THINK-ACT

Why is this egg belt so full?

The density of eggs on the egg belt is not constant throughout the laying cycle. There are periods when there are more eggs, and larger eggs. These are high- risk periods, because the belts can become overfilled rapidly. Make sure that the belt runs regularly, at least twice a day. Monitor egg density and modify run-timing accordingly.

Dust stripes

Dust stripes occur in significant numbers. The cause is usually dust on the egg belt. A fresh and still moist egg picks up dust easily. Dust can get onto the egg conveyor belt in three ways:

1. The hens dust bathing in the afternoon can raise a lot into the air, and it settles on the belt.
2. Young hens release a lot of tiny feathers and skin cells into the air, that can cause a lot of dust in a restless flock.
3. A lot of raised dust might be getting into the house just before closing an outdoor run. Then, once the hatches are closed, the air in the house becomes still, and the dust settles onto the belt.

Clear dust stripes, resulting from a dirty egg belt.

Prevent dust stripes with the following measures:

- A brush at the end of the egg belt.
- Run the belt through half its length one hour before the light goes on (using a timer switch) In that way, the clean side is at the top and the dusty one under.
- Run the egg belt immediately after the lighting comes on. The first eggs might encounter some dust but the rest will go onto the dry and clean underside of the belt.
- Adjust the ventilation so that the dust does not settle after being raised, and more fine particles are extracted by the air system.
- Only partially close the outdoor run hatches, leaving a 5-cm gap. This allows time for the ventilation inlets to open and have a smooth transition of airflow. After perching, it is peaceful in the house and then you close the hutches fully.

Fitting a brush under the egg belt will continuously clean the belt while it runs.
It is a simple and very effective solution.

Currently, most egg belts are made of plastic with an open mesh structure (left). That makes them easy to clean. In the past, jute belts were popular (right), but they got dirty quickly and were difficult to clean.

Feathers

Hens sometimes loose feathers. It is a natural process. Feathers can get stuck in a nest mat. Then they will stick to freshly laid and still moist eggs. Egg savers are useful in cage housing systems. They hold back the egg until it is properly dry.

This is not a picture of delivered eggs, but ones that have been selected out. There is nothing wrong with the eggs, but the sorting machine sees them as having dirty shells. And that means feathers on eggs cost the farmer money!

This poultry farmer has fitted a vacuum cleaner above the egg belt, to remove dust and feathers.

Some farms have fans to blow feathers off the eggs. But that is only treating the symptom. You should find and remedy the source of the problem, by ensuring clean nest boxes with an open construction.

LOOK-THINK-ACT

How do you get feathers on eggs?

A freshly laid egg is always a little moist, allowing feathers to stick on them easily. Ensure that your hens have good and healthy plumage, and that the nest boxes and egg belts are kept clean. In cage housing systems, egg savers can hold back the egg until it is properly dry.
Sometimes, consumers see feathers on eggs as a sign of quality, signifying in their minds that the eggs have come from hens which are really housed in aviary systems or free range.

Cracks and fractures

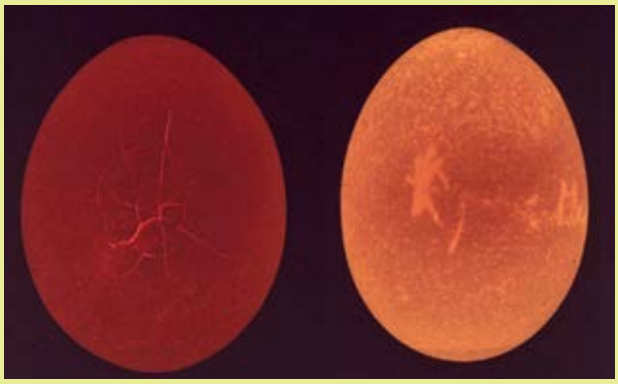
Cracks and fractures in the egg can be a signal of problems with the nest floors or the egg belt. But you will also see a lot of damage that can originate from egg lifts or packers. Look carefully at the location and type of the damage. A dent in the blunt end or pointed end of an egg maybe a signal that the egg dropped too hard after laying. The cause could be a hard point on the floor surface, e.g. a worn rod or a bare patch in the nest. Cracks on the sides often occur when the eggs roll out of the nest onto the belt and collide with each other, or they may occur during subsequent transport.

Some types of crack can occur in the uterus (the shell forming section of the oviduct) but these can patch themselves up as the egg hardens after laying. We call this a 'glued crack'. The risk of these cracks opening again, e.g. through temperature changes, is large. The crack detector will detect these hidden fractures.

Cracked eggs – we call eggs with damaged shells but unbroken shell membrane 'cracks'.

Broken eggs – eggs that have both shell and membrane broken, which allows the contents to contact air are known as a 'leakers'.

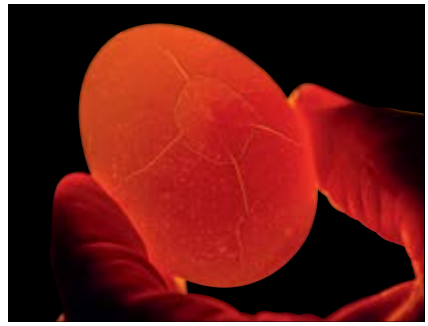
LOOK-THINK-ACT



Is the crack fresh or old?

Both eggs have identifiable cracks, but there is a difference. The lines in the shell of the egg on the right are thicker and more defined. They are already a few days old. That information is important for tracing the cause.

'Belly cracks' occur when two or more eggs collide.



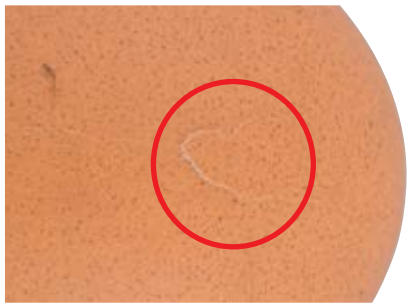
A very fresh belly crack. This happened a few moments ago during transport.

Intermingled fresh and old cracks on the body of the egg – Visible under a candling lamp. The old cracks are approximately three days old.

Old crack from which some albumen has leaked out. This dried up and glued the crack back together again. An egg inspector will recognise this egg as a leaker.

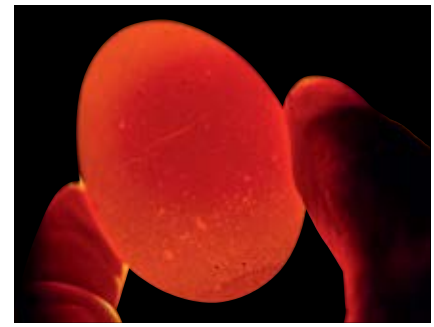
A crack on the egg's body, but the membranes are still intact, and they pull a piece of shell inward through drying (where normally this force increases air chamber size).

Old, repaired cracks on the point – this may not be visible with the naked eye. The damage was done around laying.



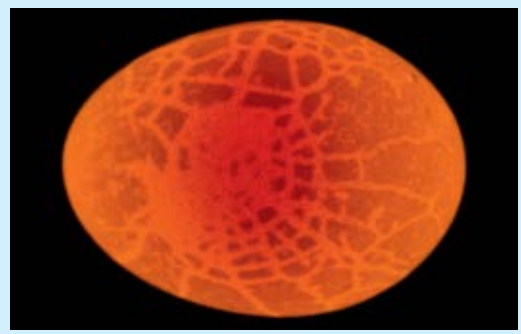
A chip that is threatening to break away.

Clear crack at the pointed side due to a hard landing in the laying nest.



A small fresh crack. A very small line.

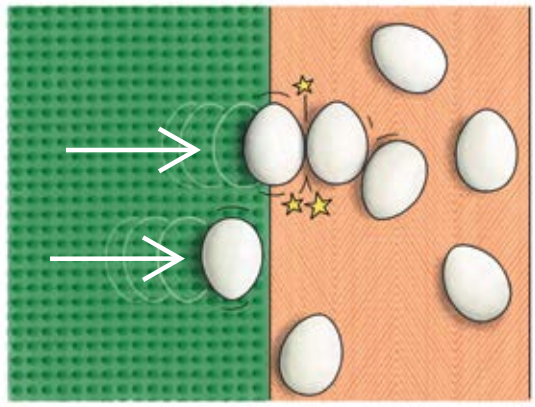
Craquelure



This egg has many tiny, old cracks. They are difficult to see on a white egg, but much easier under a candling lamp. This damage was caused by a collision during the shell formation process in the hen.

Number of cracks

You cannot prevent all cracks. But what is a normal amount? Keep records from previous flocks: is the percentage of second grade eggs normal for the age of the flock? If not, you might be able to intervene early in the laying period. A percentage of 5-10% cracked eggs (cracks) is not exceptional. Well-managed farms with young flocks can expect the level of cracks to be about 1-2%. But shell strength depends mostly on the hens' age. The percentage of 'leakers' is normally around 0.3%. Make sure you have a clear picture of the route the egg follows. Are the eggs rolling carefully enough? Are there spots where they can roll against themselves or part of the collection machinery? Are transfer points between belts supple and soft?



An egg always rolls around its equator, and that is the impact point where they bump into each other, as well as being the area most susceptible to damage.

The transport system itself is rarely the cause of damage as any sharp edges are often made of rubber and soft components. In this photo, the poultry farmer has added a bit of extra cushioning. The most usual cause of damage is caused by eggs bumping into each other and transfer points within the system. Watch for risk areas and consider implementing modifications to slow eggs down at these locations.

If there is more than 5% cracks on a farm, start looking for where they are occurring. Collect 180 eggs from the collection belts and count the percentage of cracks. Having 0-1% cracks on an egg belt is normal. Collect 180 eggs from the rod conveyor and count the percentage of cracks here too. Having 1-2% cracks is normal on a rod conveyor. If you have more cracks than this you will know which part of the collection system you need to improve.

The signals from dents and fractures may reveal the causes

A longitudinal crack in the middle of the egg points to a problem with rolling from the nest to the egg belt, or between two belts. The eggs roll against each other sideways.

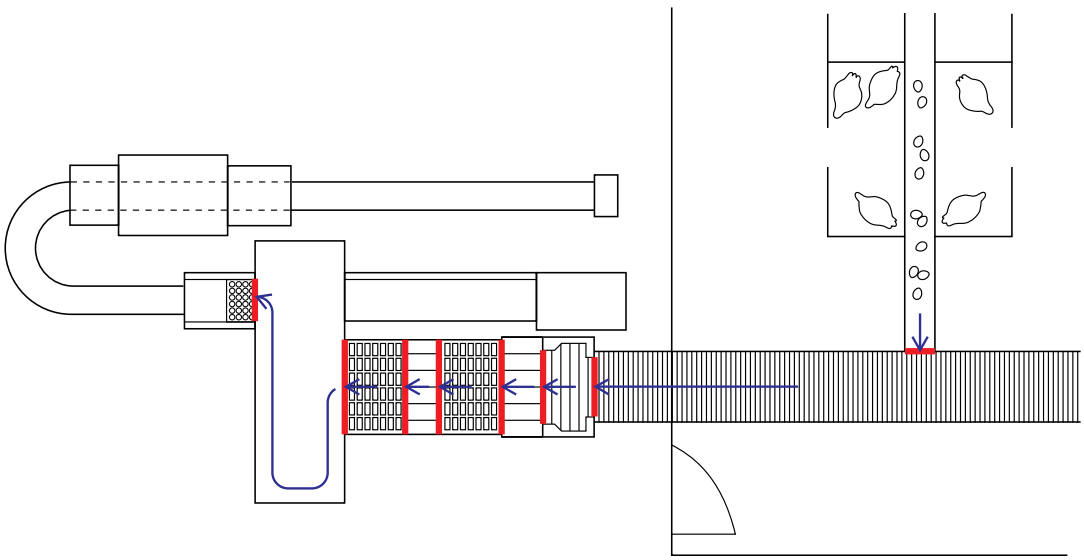
A crack at the blunt end or on the pointed end indicates a hard nest floor, excessive dropping height, or a fault in the egg turning device or dropset that puts them into egg boxes.

Transfer points cause breakage

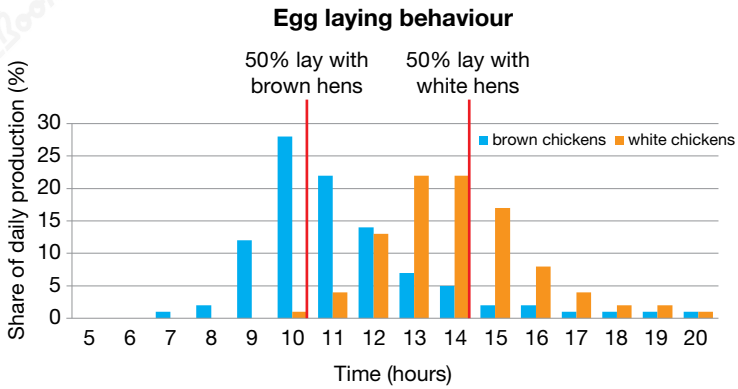
Transfer points in the collection system sometimes change the transport speed of the eggs, and such shocks can lead to cracks. Every transfer point with a transport speed change can cause between 0.1% and 1% extra breakages, depending on eggshell quality. That is why you should limit the number of transfer points and speed changes to a minimum.

A crack/hairline crack on the pointed end could be from the packer or sorting machine. If this is the case, it usually occurs in a drop location in the system, where horizontal motion changes to vertical and eggs are allowed to fall (drop) in the packing system. Pointy eggs with weak shells dropped into poorly padded packing are particularly at risk here.

It seems so logical – an egg is better off rolling downwards than dropping. Yet, you see many drop-off rather than roll-off points in egg collection systems. This will certainly lead to many cracks if the system is running at too a high speed. On the left, you see a drop off point from the rod conveyor to the transport belt, and, on the right, from the egg belt to the packer.



Even on a relatively simple farm-packer, you see that there are still eight transit points from one type of conveyor to another. Each transit point represents a risk of cracks. That is why you should check that all these transfer points are smooth and gentle.



Run your egg belt at least twice a day and make sure you do it at the right times, i.e. once when the first 50% of the eggs are laid, and again at the end of the day. The first run will therefore be early in the morning, between 08:00 and 10:00.

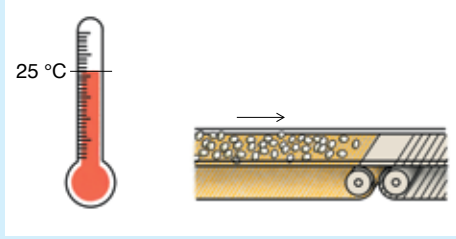
Sometimes an inclined belt provides transfer points between egg belts and rod conveyors. But if you have the choice, keeping everything horizontal is better, because there are fewer transfer points. This is a lot better for the eggs, but can be more difficult for the farmer if he or she has to bend over.

A rod conveyor is built in such a way that each egg lies in a sort of gutter. The rods are set alternately high and low. This ensures that the conveyor carries the eggs along properly, prevents eggs rolling, and distributes the eggs better.

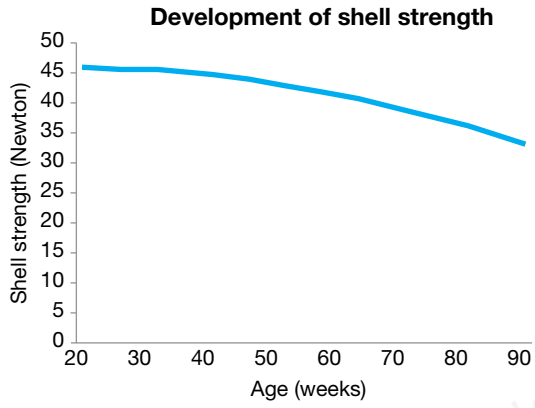
Running the egg belt and rod conveyors

Collect the eggs regularly, at least twice a day. Running the egg transport system at the right time is very important for keeping eggs in good condition. Running the system should also take account of the outdoor temperature. When the weather is warm, the eggs must go to the storage area earlier. Using the egg belt incorrectly can cause cracks. If it runs too fast and is stopped and started over and again, eggs will bump into each other much more than when the belt runs steadily, without stopping and restarting.

Outdoor temperature and running the belt



Take account of the outdoor temperature in summer. Run the belt before the temperature in the house reaches 25°C, so that the eggs are brought quickly to the storage area which should be constantly around 18°C. If you do not do this, the egg quality will decrease rapidly. Eggs subjected to relatively high temperatures (> 25°C) and exposed to humidity levels > 85%, run the additional risk of spoilage from fungal and bacterial growth, which can even get into the contents through the eggshell pores.



With older hens, running the egg belt twice a day is always advisable – Eggshell strength decreases rapidly with age.

Capacity

The capacities of all the collection system's components should match. Otherwise, you will have to put a lot of effort into adapting things to run smoothly together. For example, if you change one part you might have to modify the running speeds of all the other various components. Changes of transport speed cause more shocks and increase the risk of cracks. That will always have a negative effect on egg quality and it is a waste of your efforts.

Rod conveyors come in various widths between 30 and 65 cm. A good rule of thumb is that each centimetre of width allows capacity of up to 1000 eggs per hour.

Farmers often opt for a farm-packer with extra capacity, to get the job done quicker, especially at the weekend. But are your egg belts and rod conveyors calculated for it? If the egg belt is too narrow, the capacity will be limited, which means you will have to run it more often.

The collection system counts the eggs automatically at the collection point, and adjusts the running speed accordingly, i.e. If the eggs are passing the counter too fast, the system will reduce the speed appropriately. You can also have fully automated speed controls on all the different egg belts. A normal egg belt running speed is 36,000 eggs per hour. That works out at ten eggs per second. The belt on the left is fine, but at the right it is clearly too full. In such case you need to adjust the speed of the various belts in the system or run it more frequently.

LOOK-THINK-ACT

Is this system working optimally?

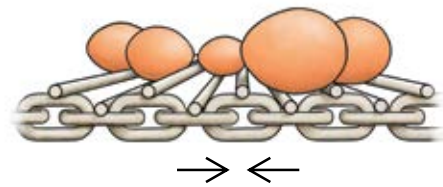
In this case the farm-packer capacity has been increased, but the rod conveyor is still too narrow. Perhaps there is an economic reason for having such a narrow rod conveyor (e.g. no cash for replacement, or that a wider one will take away space for the hens). In any case, the rod conveyor must run faster, meaning more speed changes in the system, which increases the risk of cracks.

Constant speed

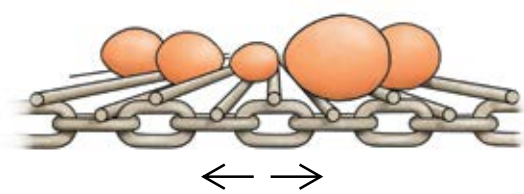
Try to ensure a constant rod conveyor speed. This is better than starting and stopping it. Acceleration can give the eggs a jolt because a lot of mass must suddenly change speed. The links stretch further apart under that load. This subjects the eggs to more pressure and increases the chance of cracking.

When stopping, the reverse occurs and the links push closer together, which also applies more pressure on the eggs.

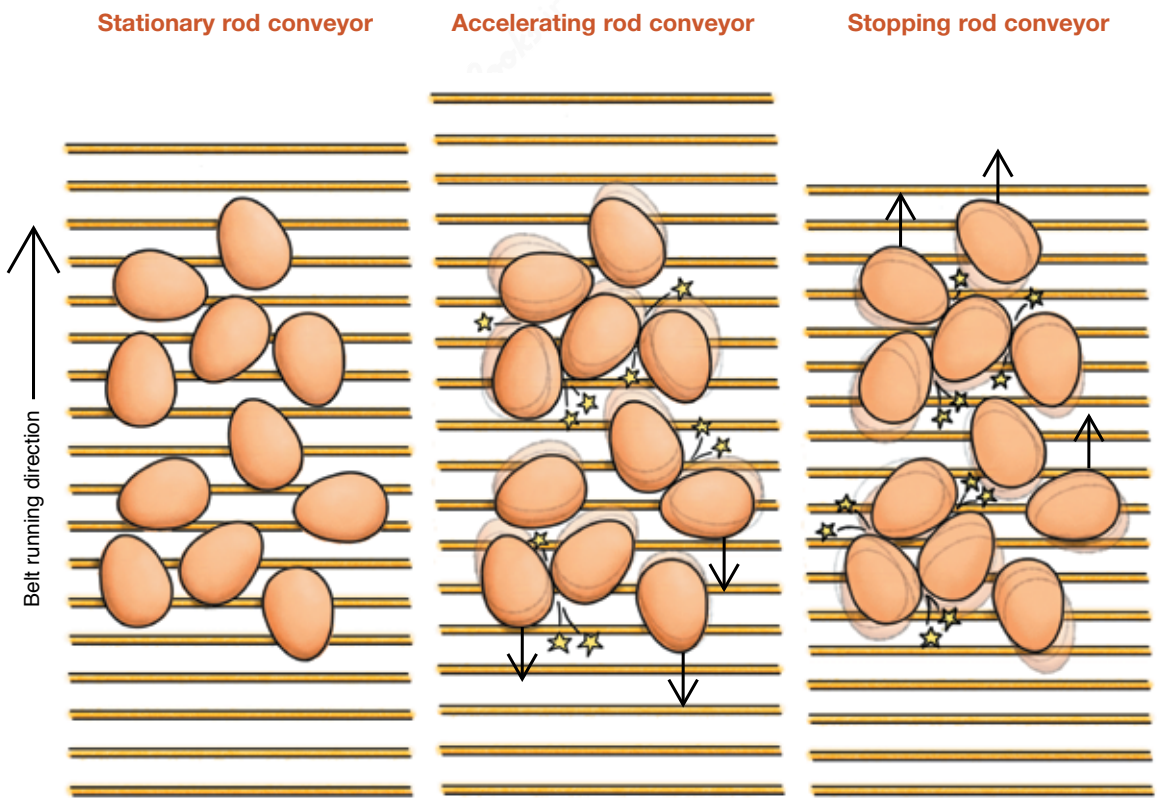
You can test the egg route by running an electronic egg through it, which will record the various pressures it encounters.



Stopping – the links pushing closer together.



Accelerating – the links stretch away from each other.



Starting and stopping is not only bad for the eggs, it is also bad for the working life of the chain itself, links which are squeezed together are tugged apart again, which means heavy loads are exerted on the connections.

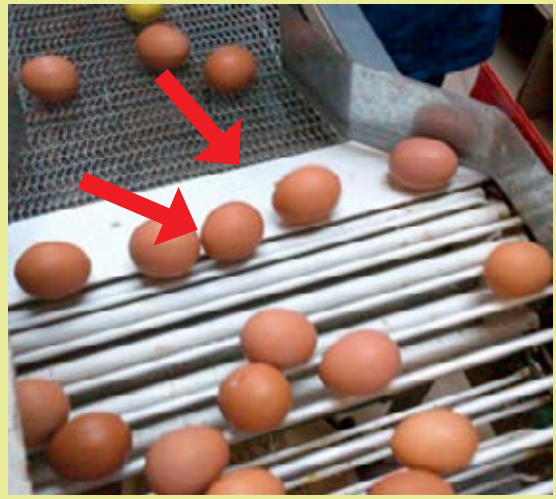
Electronic egg

When you want to detect problematic locations on your system, you can collect eggs from different points and inspect them. Every system has its own critical points. If they are not running optimally, the percentage of second grade eggs can increase significantly. An alternative method for checking for critical points is to use an electronic egg. This is a transparent artificial egg with built in electronics. The electronic egg collects data on the movement and shocks it encounters on its way through the system. By analysing this information, you can get an insight into where cracks are most likely to

The usual cause of cracks in eggs is an accumulation of bumps, rather than a single impact.

An electronic egg is a very handy tool. For reliable data, you should run the egg through the system at least six times. A specialist can check your system and provide you with a report.

An electronic egg and reader that is used to transfer and process the data collected.



An impact report of an electronic egg where the transit point of rod conveyor to collection belt is observed.
You can see some shocks in the graph because there are too many eggs in the system and an abrupt transit between the belts.

With visual inspection you throw leakers directly in a waste bin (photo above). Second grade eggs are put in a separate tray (pictured below). One employee can manage up to 10% dirty shells with visual inspection. More is no longer workable, and too many abnormal eggs will slip through. A discount on the price paid to the farmer is the result.

Visual inspection

Poultry farmers can pack eggs ready for the consumer on the farm or transport them to a packing station. But the eggs must still have coding applied before transport, to satisfy traceability requirements. In either case, the eggs must undergo quality control before packing and distribution. A manual inspection is implemented in most cases. It is primarily a visual check. Eggs with cracks or dirty shells are removed, but it is far less accurate than automated checks.

It is not only a case of removing dirty or leaking eggs that are not worth anything. You are also preventing contamination of the system itself.

The first step in inspections at packing stations is detection of eggs with dirty shells or leaky ones. That is very important, because those eggs can contaminate others. The checks can be manual or automatic.

A human inspector is able to recognise a hairline crack by subtle contrasts on the shell (easier with a white shell than a brown one). By applying a little manual pressure at the position of the suspected hairline crack, they can see it better. An expert is able to recognise hairline cracks in white eggs that are as little as 0.1 mm wide and 5 mm long.

Make sure you have a clean transport belt and a clean and well-setup packing machine. Always use clean trays.

Sticky eggs

Eggs that are stuck in the tray cannot be sorted.
How do eggs get stuck?

1. Some egg content was spilled during collection
2. Weak shelled eggs have broken during storage and left spilled white or yolk between the shell and tray.

Eggs only get glued into tray when their content is fresh. If the leaked egg content is more than 10 hours old, it has dried off and does not stick any more. The gluing effect is the strongest when eggs stand on a palette for more than 24 hours.
You can prevent glued eggs by stopping the packer and cleaning it well immediately after an egg has leaked in it, and then continuing the job.
Stuck eggs have nothing to do with the cleanliness of the plastic trays (but moulds do). You do not have this problem with pulp trays.



One egg that is too large in a tray can cause breakages, and thus stuck eggs.

Remove eggs that are contaminated with leaked content from the belt, and ensure they do not get into the trays.

The tray size must match the egg size. An egg that is too large for the tray will break because it will only rest against the side of the pockets in the tray. On the other hand, if the eggs are too small for the tray, they will 'rattle' around during transport.

A leaking egg in the tray above has contaminated this one. This egg will either be rejected by the egg inspector, or it remain stuck in the tray.

LOOK-THINK-ACT

Why is this egg stuck?

This egg is still in the tray because it is stuck in there. The cause could be a break in the egg that has let egg white run out. Egg white will glue the egg to the tray. The cause is often egg white from another egg that broke during collection, but it could also originate from a leaker in the tray above.

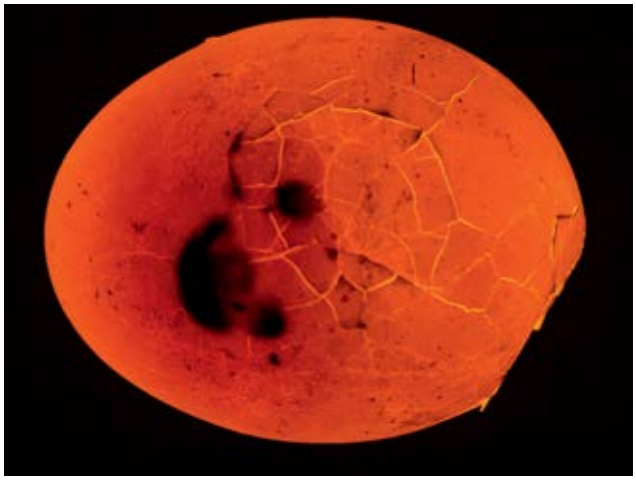
Dirty trays are a source of mould infections. Make sure your trays are clean, and check them before use.

Moulds and eggs

Pay careful attention to egg storage. If cold eggs come into a warm environment, they will 'sweat' i.e. the eggshell becomes moist with condensation. A high moisture content is an invitation for moulds to grow on the outside of the shell; the porous shell means the fungus can then get into the egg and contaminate the contents.

Eggs with serious mould contamination This entire batch is rejected for that reason.

Not only can the trays have mould contamination. Do not forget the dividers!

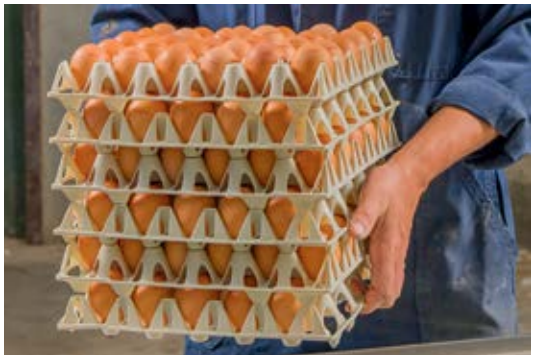


A broken egg with mould formation, seen under a candling lamp.

An egg contaminated with a mould is unfit for consumption.

Delivery to the packing station

There are clear rules associated with delivery to packing stations. For example, the obligatory use of certain materials (e.g. plastic egg trays) and how varying size categories and second grade eggs should be offered. The latter allows the station to handle them separately.

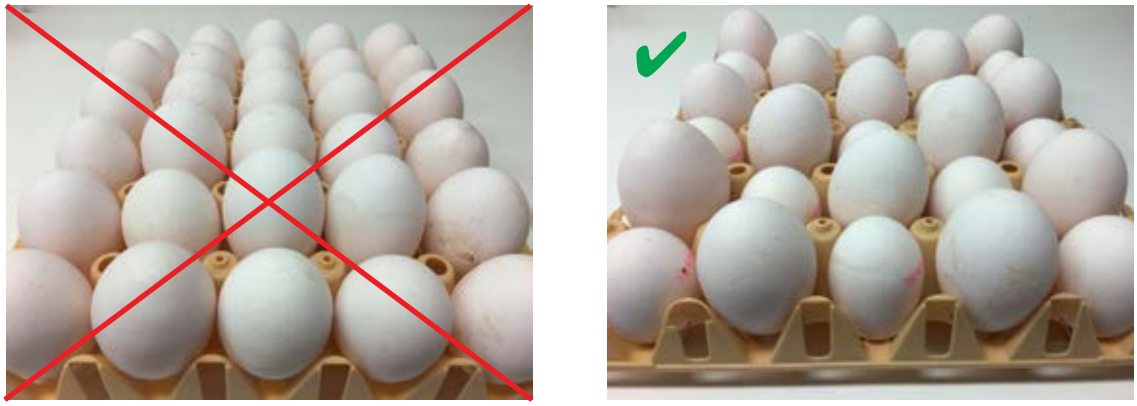


Sturdy plastic trays, not stacked higher than six layers, will prevent unnecessary cracks.

Once removed from the stack and trays, the eggs are put on the belt, which transports them to the dirt detection unit.

Eggs are usually delivered to packing stations in stacks of plastic trays, with six on top of each other per layer. There is a dividing plate before the next layer. The operation repeats until there are five layers on the pallet.

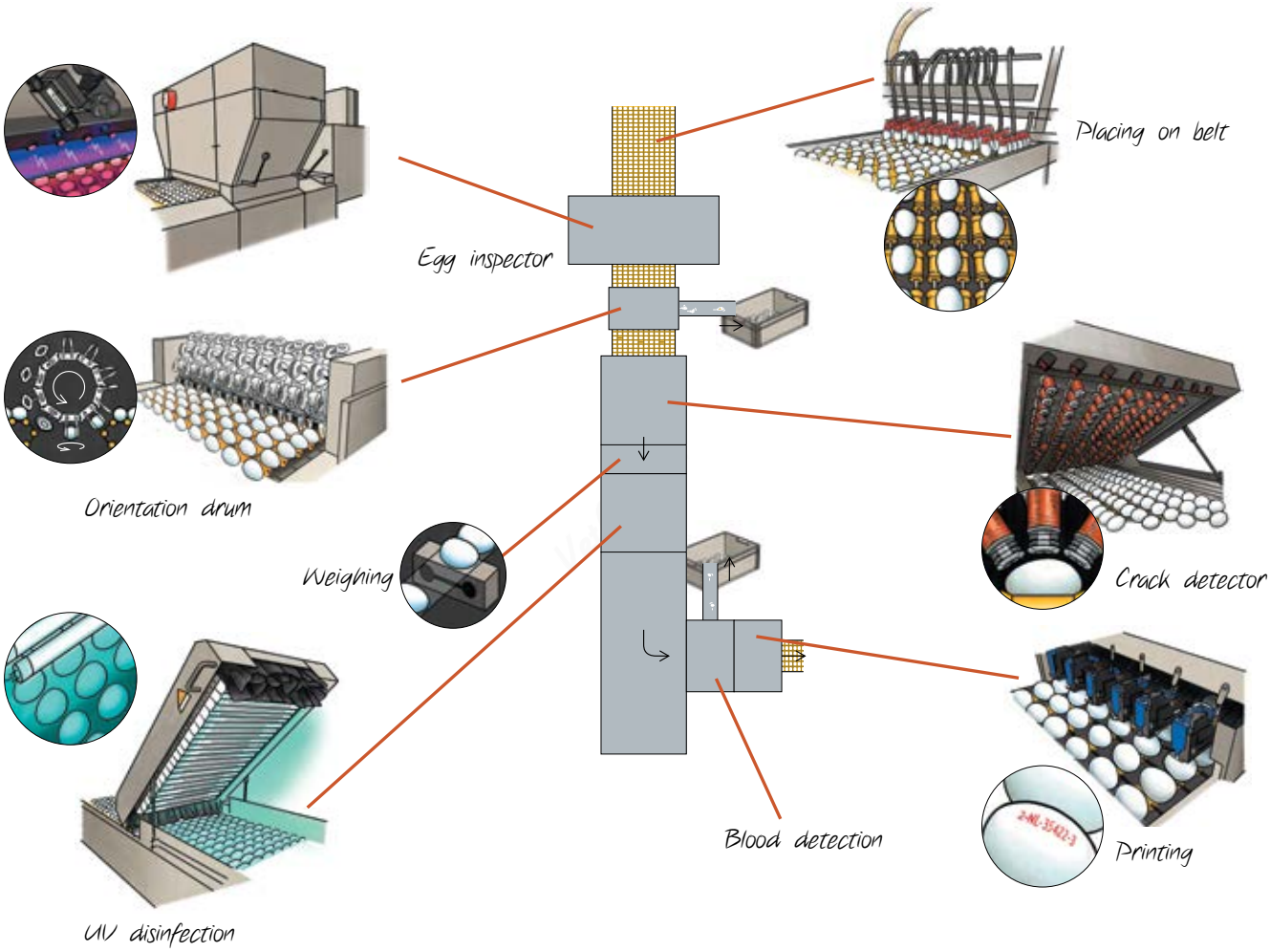
Abnormal eggs, like double yolkers, are put on top. That prevents the risk of their abnormality causing them to break within a stack. It also makes it easier to sort them out for handling as second grade eggs.



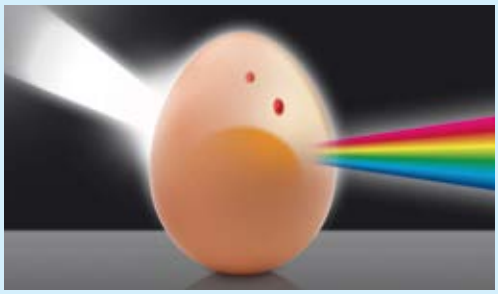
Double yolkers and very large eggs will break if mixed with the others. But don't put them all in the same tray (left). The eggs touch each other with a risk of breaking. They should put in the tray with large and small eggs alternating in a checkerboard pattern. This way there will not be any large eggs next to each other, which prevents them from being broken during transport.

Detection of unwanted eggs

Eggs delivered to the central egg belt should be pre-sorted, with any that have unwanted features removed. You can do this manually with a candling box, or by using automatic detection devices. In an automated system, the eggs first go through the 'egg inspector', which has special light and cameras to detect dirty and leaking eggs. Then a crack detection system assesses the egg-shell quality by tapping each egg at 16 different spots and analysing the vibrations the egg makes. This is a quick way to pick out cracked and broken eggshells. Then the system weighs the eggs. Light spectrum analysis allows blood spot detection in eggs. Finally, the system applies specific codes, which where applicable, sorts the eggs by weight, and possibly by shell colour.



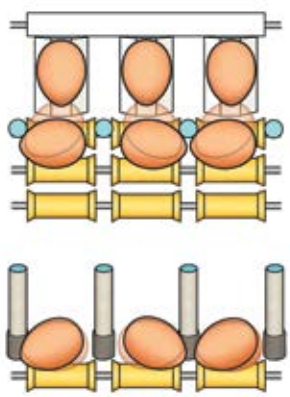
Blood detector



The blood detector looks through the egg using different types of light (VIS/NIR spectroscopy). The amount of dispersion of the light gives an indication of blood inside the egg. The apparatus should be at the end of the line for the most efficient use. The through-flow of eggs is the steadiest there.

Direction and crack detection

An automated system rotates the eggs so that its point is directed towards the rear. That allows efficient inspection and smooth transport.
Then an acoustic crack detection system determines if an egg is cracked.
The percentage of eggs selected and the measured breaking strength tell you whether you have to look for a problem among your hens or in the collection system. If a lot of cracks are found, but crack strength is OK, the cause is the system. If there is a high number cracks and a low crack strength, it's the hen.

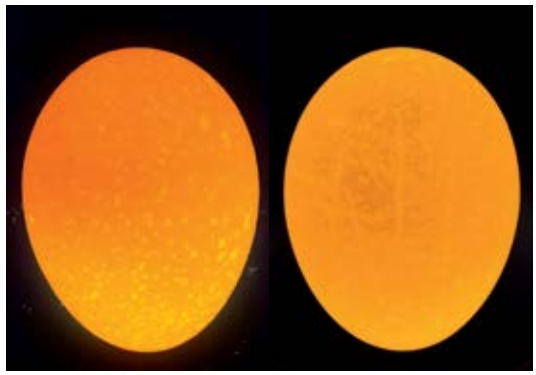


The rollers ensure that the egg only rolls in one direction. Then the egg encounters an obstacle, which causes it to rotate in the correct direction, with its pointed end towards the rear.

Acoustic crack detection is a well-known method. For example, if you use a pencil to tap on a glass with a crack, it sounds different to an undamaged one. The crack detection system gives the egg multiple soft ticks on different locations, and can detect a cracked egg with 90% reliability. The test gives a rating from 0 to 30. Zero is a good egg without hairline cracks, 1 indicates a small hairline crack, while 30 means there is a big open crack, a leaker. The system will also tell you the position of the crack on the egg. If the data shows that it is often the same point, this can help you to work out what causes the cracks in your system.

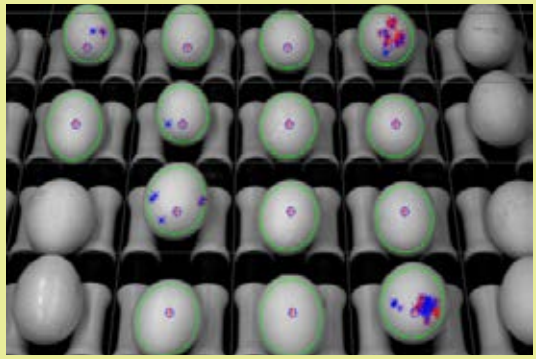
Marble test

Back in the nineteen-fifties, people used marbles sometimes to test eggshell strength. The tester placed an egg under a glass tube. Then they dropped marbles down the tube and onto the egg from a set height, continuing until the egg broke. The number of marbles was then the indicator of shell strength.



In hot countries eggs harden off slower. If mechanical forces are exerted on the egg, like by the crack detector, these become visible through candling 24 hours after the event. Left the normal structure, right an impact pattern on the egg.

Even without an acoustic crack detector, you can still test eggs for cracks. If you knock two eggs against each other very gently, you can hear it for yourself.



The egg inspector uses cameras and special lighting to detect leaking or contaminated eggs on the supply belt. These defective eggs are then selected out of the system.

Wet and leaking eggs are removed immediately. That is why you see empty spaces sometimes in the graders.

Eggs with cracks or uneven shells are not saleable as grade A eggs. But they are still perfectly suitable for the processing industry, as they will be pasteurised before use e.g. for use in baked goods.

Leaky eggs in pulp trays can have nasty side effects. Even though these trays cannot be washed, they are often reused. Spilled egg content attracts pests, e.g. flies. Here you can see maggots in a pulp tray.

Egg code

There is an egg code stamped onto every egg produced, in countries where it is obligatory, e.g. EU countries. The code shows the country of origin and the husbandry system. It also includes the code for the farm and the actual house where the egg was laid. This allows you to trace the egg back to its source. The code must be easily legible and not easy to wipe off, but it does not have to withstand boiling. The ink has to dry fast for the ink not to run out or stain.

The first digit represents the husbandry system the hen is kept in:

0. organic egg
1. free-range egg
2. aviary/barn egg
3. cage egg

The second part of the code represents the country of origin:

AT Austria	EE Estonia	IE Ireland	PL Poland
BE Belgium	ES Spain	IT Italy	PT Portugal
BG Bulgaria	FI Finland	LT Lithuania	RO Romania
CY Cyprus	FR France	LU Luxemburg	SE Sweden
CZ Czech Rep.	GR Greece	LV Latvia	SK Slovakia
DE Germany	HR Croatia/Hrvatska	MT Malta	SL Slovenia
DK Denmark	HU Hungary	NL the Netherlands	UK United Kingdom

The last seven characters of the code are split into two parts:

- the first five digits are the code for the poultry farm
- the last two are the number of the house

For example: 2-NL-1234501 means that it is a aviary/barn egg from a Dutch producer with farm number 12345, and the egg came from house number 01.

The egg code in the EU is compiled as follows: farming system - country - farmers code and poultry house number

Sometimes, for certain customers, packing stations add a 'use-by' date to the data printed on an egg.

Eggs from a salmonella positive flock are coded 2-NL-00000. This means they go directly to the processing industry. You cannot sell these eggs as grade A eggs for consumption nor as 'liquid' eggs, so only in powder products (sterilised).

In respect of food security, special ink that is fit for human consumption is used. It is called 'food grade ink'. The ink is based on water, alcohol, and colourings (with an approved E-number). Take into account the shelf life of the ink.

The difference between stamping and printing

In the EU, it is obligatory to apply the egg code except for on-farm sales directly to consumers. The egg code can be applied to the egg in different ways, stamping or printing. However, the terms are often used interchangeably. The traceability code is often printed or stamped on the poultry farm in the Netherlands, Germany, Belgium, and the United Kingdom. In the rest of Europe, it is done usually at the packing station. In countries where there are various types of eggs available, e.g. cage, aviary, free-range, and organic, the best market protection lies in source coding. Egg printing is not simple. The environment is often damp, dusty, and occasionally dirty. And the printers need to keep functioning with as little down-time as possible. The processing rate is very fast, and usually you are not allowed to supply unprinted eggs to the purchaser.

Stamping

Stamping systems based on silk-screen produce high print quality, and are very suited to printing logos, company names or traceability codes.

- There is no possibility for flexible information (like a date).
- Refilling ink is a bit more difficult than changing an ink cartridge.
- Larger printable area (20 mm diameter)
- You do not need electricity.
- Increased risk of poor or illegible print.

Cartridge based printing

Cartridge based printing systems have easy operation and high print quality.

- Data flexibility – e.g. it is easy to change the date.
- Cartridges are easy to change.
- The maximum printing height is 5 mm.

Continuous ink jet printing

Continuous ink jet printing system (CIJ) prints at very high speeds and do not use cartridges.

- Very high speed printing is possible
- The maximum printing height is greater
- Lower print resolution
- Reusable ink reservoirs reduce ink consumption, but the original purchase is more expensive
- Changing colours is difficult

Relative costs of various techniques

	Purchase	Maintenance	Ink
Cartridge	$$	$$	$$$
CIJ	$$$	$$$	$
Stamping	$	$	$$

A stamp with a flexible printing face. There is a mirror image of the stamp visible on the top of the convex membrane. When there is a little pressure applied to the stamp, this membrane wraps around the convex shape of the egg. And that results in a high resolution print on the egg.

New – Laser marking eggs

There is also the possibility to laser-engrave eggs. This is clearly visible on brown eggs because it damages the pigment layer and the white shell below shows through. You do not need ink any more, and it does not wash off. It is still not clear if burning away part of the protective layer has a negative influence on the shelf life of the egg, or presents an infection risk.

Printing position

Opinions vary about the position of the egg code. Printing on the long side ensures that the code is applied better. The curve is slighter, and thus provides a better printing surface to allow high capacity printing. On the other hand you do not see the code immediately when you open a box.

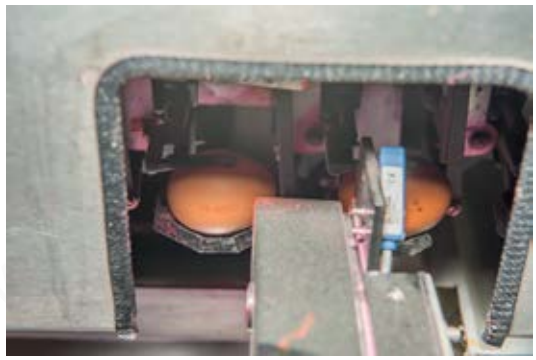
Points for attention:

- What do you need to print on the egg? Printing dates is only possible with an electronic printing system. But a stamping system is best for high resolution logos.
- Hand packing systems have different requirements than packing machines.
- The printing system must integrate well into the packing/sorting machine.
- What printing speed/capacity is required for the eggs? This determines the choice of system.

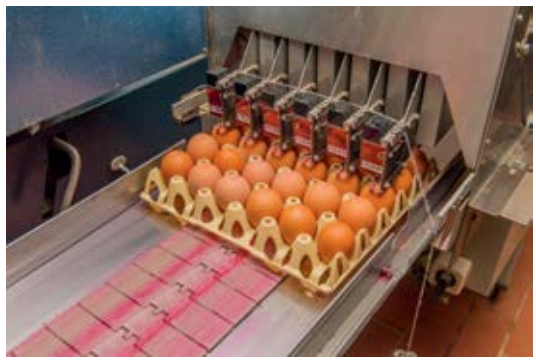
Egg marketing and branding

Of course, you could print all kinds of other things on an egg, besides the obligatory code. For example, the businesses name or logo, the quality mark and logo, and many other types of messages. And that allows you to emphasise certain qualities of the eggs. For example, the eggs could be Omega-3, organically produced, or carry a brand name that stands for high nutritional value.

A print half way onto blunt end of the egg in a farm packer. The printers are equipped with a start sensor. If the sensor is dirty, misprints will occur, and eggs will be missed totally or incorrectly printed.



A stamp on the long side. The position of the printing on an egg is primarily dependent on the most suitable position for integrating the printer into the packing machines. The long side of an egg provides a larger surface, which makes the print easier to read and it makes printing with higher speed possible.



A stamp on the blunt end. Eggs go into trays with their pointed ends facing down. Thus, a stamp on the blunt end is the most visible. It is also easiest to apply print to the blunt end when working manually or using relatively simple machines. Because of the rounded surface, a long text is not possible.

Cleaning stamps and cartridges

Cleaning stamps and ink cartridges prevents most misprints. You should do it at least once per day and whenever you see that the print quality is decreasing. The cause is often dirt, dust, moisture, or egg contents.

Misprints

Half a print. The cartridge does not make good contact with the print head. Take the cartridge out and put it in again. When you hear a click, the cartridge should be properly placed. It may happen that the print head or the contact points are worn down, but this is rarely the case.

Print too short. The printer has been just too early or too late. Move the sensor slightly forward/back or re-program the printer so it prints slightly earlier or later.

A faint print. The print head is too far away from the egg and must be brought closer to the egg. This should be 1 mm, so that the print head nearly touches the egg. With different egg sizes it will sometimes happen that the print head touches the shell. If this happens not more than 10-20% of the eggs this is acceptable.

If a broken egg leaves egg content on the print head, it cannot print well anymore. Due to the heat, the protein coagulates on the print head, and this becomes clogged.

Smudged print caused by unsuitable ink or a dirty shell.

Illegible code through ink bleeding on the print. That can be caused by excessively damp storage or using non-original egg-printing ink.

Stretched out print – The egg passed the print head with an uneven speed.

The original print on the egg was illegible. And that is why it was reprinted at the packing station.

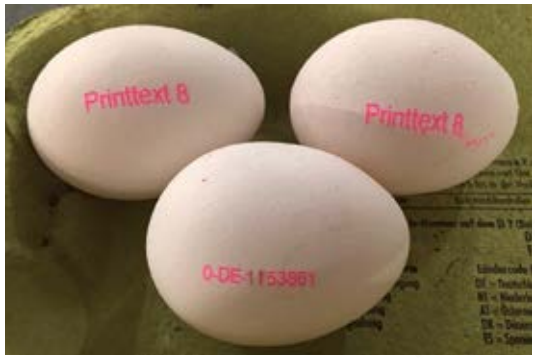
An egg that has accidentally been printed twice. Look for the cause – did it run through twice? A fault in the printer? Did the egg get stuck somewhere in the system?

Double printing but two different prints – This egg was printed on the farm, but its destination changed and the packing station printed it again.

Using stamps for too long diminishes the quality of the print. The membrane is worn. The membrane of a stamp should be able to stamp 250,000 eggs. After this the quality deteriorates rapidly: in some places on the membrane, the ink will pass faster while on other points it is hindered. Often, stamps are used for too long to save costs. Replace stamps in time for optimum print quality.

Other defects with stamping

Half a print can also occur using a stamp. The position of stamps in the frames or the position of the stamping machine itself is not good. Reconfigure so that the stamps are just above the eggs. Sometimes lines are too bold because the stamper is set too low, making the contact time of stamps with the egg too long causing too much ink to flow on the egg.



Sometimes you see very strange prints on eggs at the sorting station. In this case, someone has messed around with the printer buttons, and the wrong text was applied. Check the printing regularly during sorting/packing.

A half print – This is the result of incorrect printer settings. Printing has occurred either too early or late to this egg.

A large part of the stamp is not visible. Change the stamp on time!

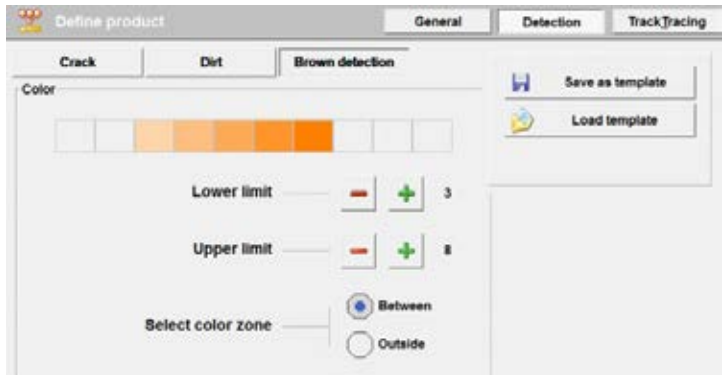
The irregular surface of this egg (infected with IB) makes the print difficult to read.

Sorting, grading and packing

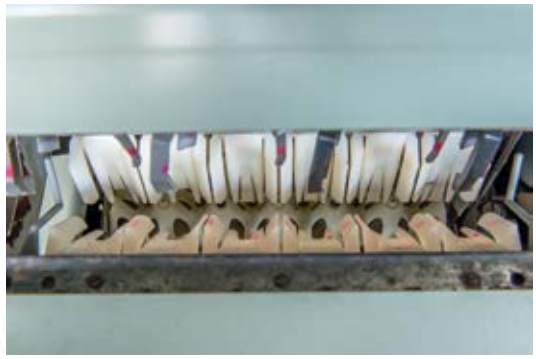
Sorting eggs is a legal requirement if you want to sell them as A grade eggs, and it is nice for consumers to find the same sort of top quality eggs in the box. Sorting and grading of eggs is based on weight and quality.

When sorted, the eggs are put carefully into boxes. This must be carried out in the correct way, because an egg placed poorly in an egg box could break and contaminate the others with its contents.

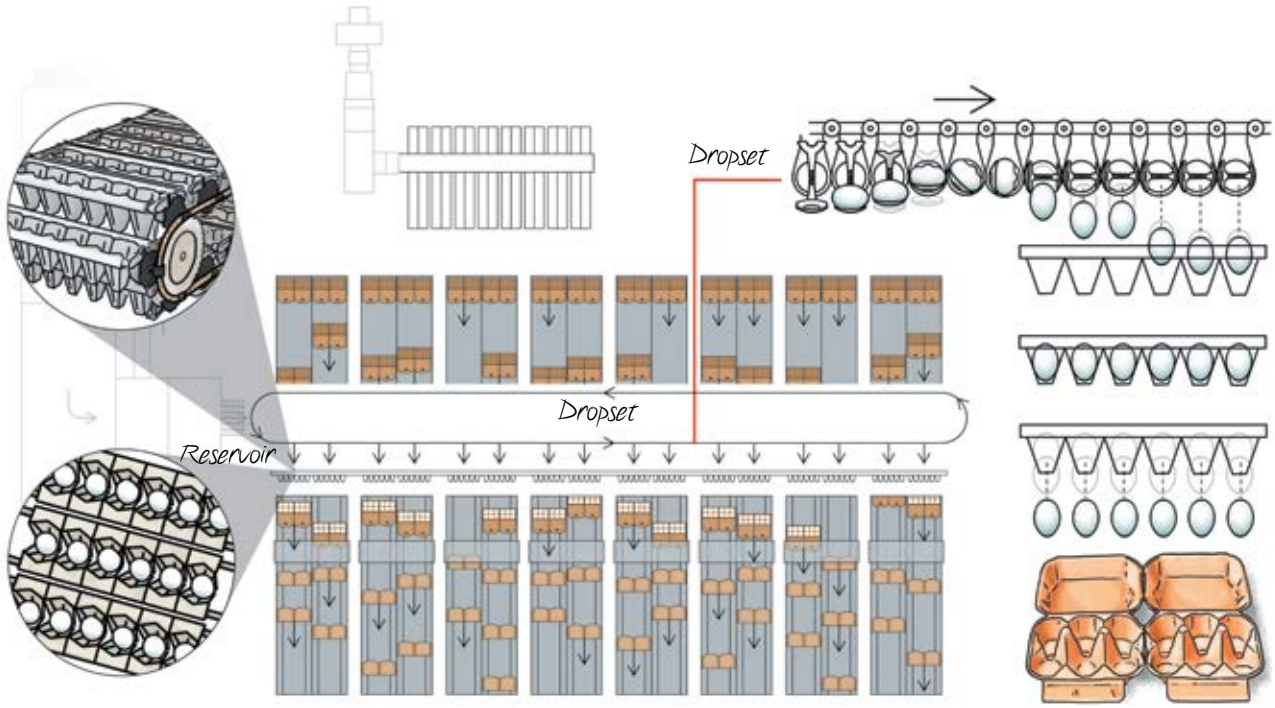
Eggs that do not meet the quality requirements for consumer eggs are used in the processing industry. In many systems, every egg is handled individually. Doing that has the advantage of delivering 2% more saleable eggs, because cross-contamination is minimalized and the eggs are handled more carefully.



Detection devices make it possible to sort eggs based on shell colour. The computer compares different colour intensities on a scale of 0 to 9. 0 is white, 1 very light brown, and 9 is dark brown.
You can separate colours and send them to a particular packing belt. In that way, you can have matching coloured eggs in each box. Uniformity of colour however is rarely a requirement in practice.



The dropset fingers wrap around each egg, and then drop it very carefully into the package. Very occasionally, you see stripes on the eggs, primarily white ones. In many cases, the dropset fingers are dirty. Clean them regularly.



The last part of the process - the dropset 'drops' the eggs into the packaging.

Washing method:

1. Egg washers spray the eggs with warm water, sometimes with an added sanitiser
2. Then the machine brushes off the dirt.
3. Finally, the eggs are rinsed, sometimes with chlorine added to the rinsing water (for disinfection), and dried with large hot air blowers.

Washing

In some countries, eggs are washed before packing for consumers. European regulations do not allow the washing of grade A eggs (except for hatching eggs), while it is obligatory in the United States. Sweden only allows hot water washing, so that contraction will not suck bacteria into the egg when the eggs cool down. The water used for washing is 40-45°C. Keeping washed eggs fresh, requires cooled storage and refrigerated transport or coating in a film of oil, because washing might damage the protective layer on their surface, i.e. the cuticle (or bloom). Unwashed eggs do not need cooling during storage and transport. The cuticle keeps them in good condition.

Washing eggs is not permitted in the EU for the following reasons:

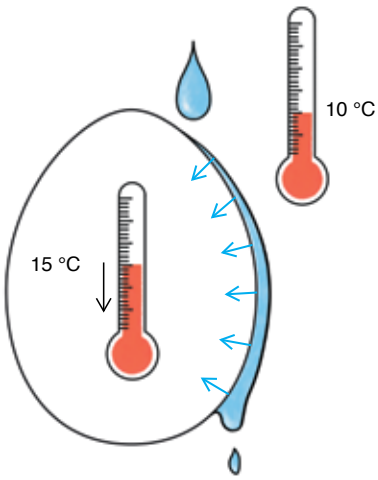
1. It can disguise second grade eggs.
2. Washing with cold water causes the egg content to contract, which can suck bacteria on the surface of the eggshell into the egg contents.
3. It might damage the natural protective layer, the cuticle, and that decreases the shelf life of eggs unless they are cooled.

In times gone by, egg washing was necessary, because there were numerous dirty eggs. Nowadays, it is no longer necessary, because of the high standard of farm management and high quality nest boxes. On the left a small scale egg washer (off line), on the right a large scale washer (in-line).

Brush drier. Soft brushes swipe the water of the eggs while ventilators cause a constant airflow to remove the humidity.

Air dryer. By high velocity airflow the water is removed and vaporized without touching the eggs.

The thickness of the protective cuticle is probably a little thinner each time an egg is washed. Left – an unwashed egg treated with a colouring that is absorbed by the cuticle. Right – the same egg after washing – you can see that the entire surface is less green.



Eggs should be washed with water that is slightly warmer than 40°C. Any washing with water cooler than this causes the egg content to contract, drawing in contaminants from the shell surface.

Sometimes devices known as cutting nozzles are used during washing. These are powerful water jets, which will, on purpose, break weak shell. So an extra selection against weak eggs.

Egg washing varies by country. Regulations in the USA require the use of sanitisers for washing eggs. In Japan, there is no sanitiser used for egg washing.

CHAPTER 9:

The end user

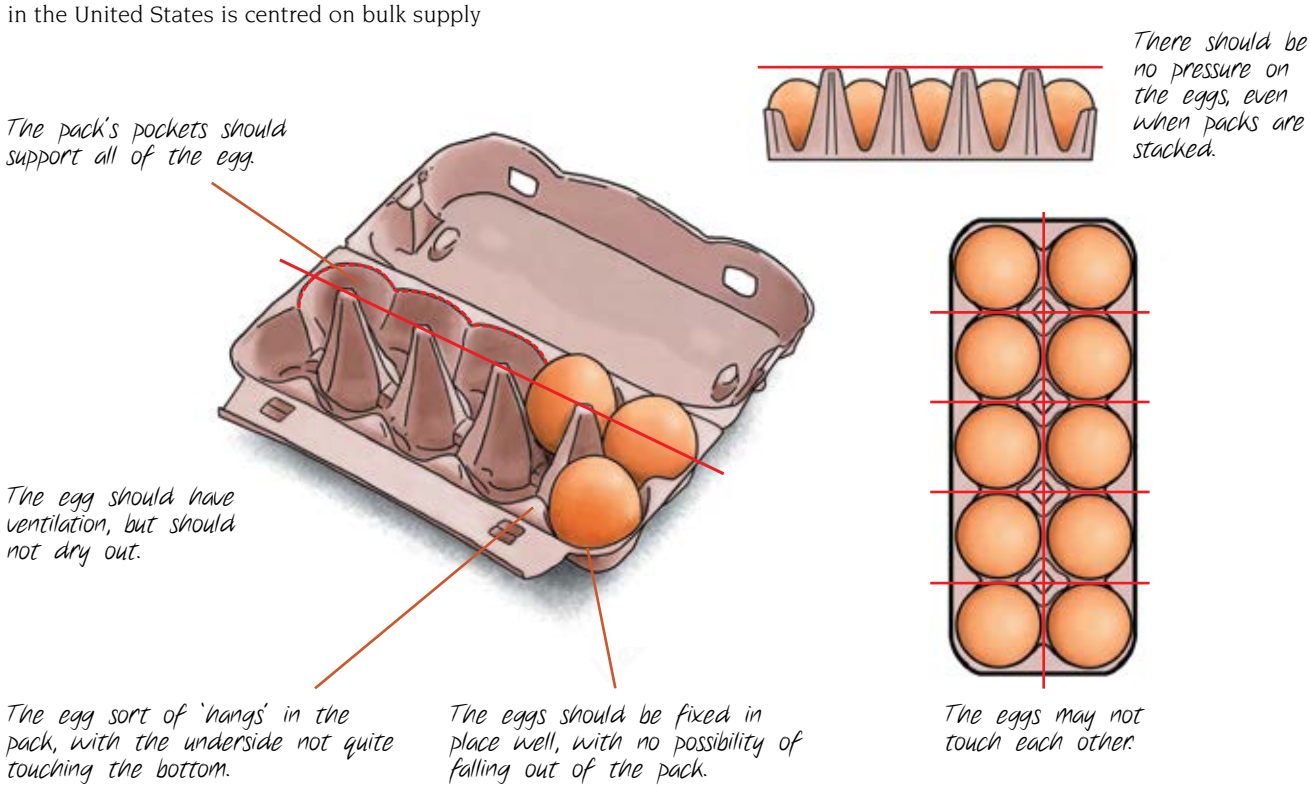
Consumers like to see a nice round, sturdy, and beautifully coloured yolk, and compact thick albumen.

The egg arrives at its destination, the end user. The egg must satisfy the customer's expectations (the processing industry or consumer). Good, cool, and dry storage conditions are very important for maintaining a high standard of quality. Use of special egg boxes is preferable.

Consumers have different preferences than the processing industry. Consumers have a choice of different husbandry systems, formats, etc. The processing industry's main requirement is large eggs: larger eggs means breaking fewer eggs for the same volume of egg contents. Processing eggs and egg products comprises breaking, filtering, mixing, stabilising, blending, pasteurising, cooling, freezing, drying, and packing.
That means that the egg must be clean inside and out, should have a strong shell that breaks well, a sturdy, well-enrobed yolk, and not contain any harmful bacteria.

Packaging

Well thought out packaging is essential for keeping eggs in good condition during storage and transport. Egg packaging should be easy to handle and transport, ensuring minimum risk of damage and cracks. Europe is the most innovative in terms of the egg packaging market. The market in the United States is centred on bulk supply in a defined limited price range, which leaves less room for innovation of packaging. There are hundreds of packaging designs. Well thought out packs can add value to the product, which allows eggs to compete in higher-end markets where higher profit margins are anticipated.



Eggs of different sizes in transparent packaging. If the egg touches the bottom of the pack, it can break when the packaging is put on a hard surface (left). If it is suspended in the pack, it can absorb the shock a little. But if the egg is too big for the box, and it is higher than the pocket pillar, the lid can touch it leading to breakage (right).

The material strength of the boxes is very important for stacking. You will often see high points on the pillars in boxes made of pulp, which take the pressure in stacks. But in many cases a combination of protrusions in the lid and lower half of a synthetic egg box will meet to offset any direct pressure being applied to the eggs and create the strength of the box.

Packaging requirements

Egg packaging and the eggs within it, are exposed to mechanical loads such as vibration, shocks, bumps, and stacking pressure, during transport and storage. Tests to check that the packaging can withstand such loads and protect the eggs properly often include a practical test in transport, or laboratory trials that mimic practical situations.

The pointed end of an egg is the strongest and the air chamber is formed at the blunt end. These are the reason why eggs should be stored point end down. However, if you see a photo or drawing of an egg, it is usually presented with the point upwards…

Transparent egg boxes

There are special anti-tampering regulations in many countries. Product packaging must allow the consumer to see that the pack has not been opened previously and that the product is undamaged. That is why packs are transparent and carry a seal in some countries (e.g. Japan).

Every country has its own way and means to transport eggs and deliver them to consumers. Transport in baskets leads to unnecessary cracks and breakages which can increase up to a level of 20%. Damage in trays is less likely to occur and is around 2%.

A new development in durable packaging - fully recyclable egg boxes made of 50% grass and 50% recycled paper. Producing this packaging cuts water use by 60% and reduces CO_2 emissions by 15%, compared to traditional egg boxes.

There are also environmentally-friendly biodegradable egg boxes, made of injection moulded starch and cellulose fibres.

Materials – pros and cons

Pulp egg boxes/trays:

+ the eggs do not dry out quickly and are well protected
– paper pulp absorbs moisture, and lacks ventilation
– origin of paper is unclear (food security: chemicals, old ink)

Plastic egg boxes/trays (polystyrene):

+ easy to clean, and good ventilation (trays)
– less shock protection
– because the material cannot absorb moisture, eggs can sweat if storage temp too high

Paperfoam (starch and cellulose):

+ light weighted, compared to pulp
+ environmental friendly
+ good moisture absorption
– more expensive than the alternatives

Suitable packaging

A pack for small eggs, open and closed, with a pillar – It is clearly too small for a large egg. It is packed tight in there, increasing the risk of breaking.

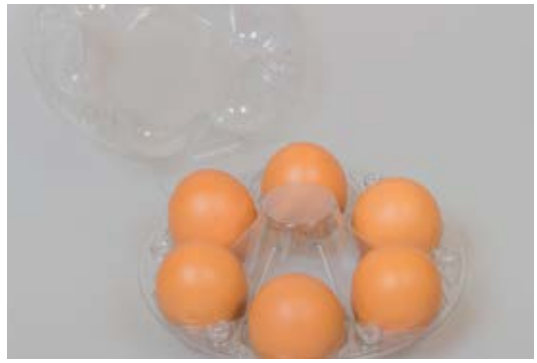
A pack for large eggs, open and closed – It is clearly too big for a small egg. It is loose in the pack which increases the risk of breaking.

The size of packages

The size of the packages depends on the market. In areas where few eggs are consumed, one works with smaller packages of four or six. There is often an associated marketing goal. With small luxury packages, you can ask relatively higher prices, because consumers relate more to the price per pack and rarely calculate the amount per egg.

Small pack for 4 eggs.

Pack for 6 eggs.



Pack for 6 eggs in a round pack (Rondo).

Pack for 10 eggs.

Pack for 18 eggs.

Pack for 20 eggs.

Tray pack with 30 eggs – These are usually only used for transport from farm to packing station.

Designer packages

Nice packaging folded in triangular form.

Eggs hanging in a cardboard construction

Each egg protected in a triangle, which can be rolled up into a hexagon.

Otilia Erdélyi developed this revolutionary packaging for a design competition in Hungary. The aim was to use as little packaging material as possible. The eggs are clearly visible. This packaging has never been put into production.

Egg boxes as toys

Besides functionality - protecting eggs - the packaging has a presentation value. Beautiful packs sell better. There are even packs that have a second life as toys, children can use these egg packs like Lego. That's why the packaging contains 8 eggs.
There are even starter packs developed with empty boxes, because you would have to eat a significant number of eggs before the kids have enough blocks to play with.

Special packaging for eggs from the Rondeel housing system. These contain 7 eggs.

Flat egg cartons that can easily be folded into the desired shape.

Baker's dozens

A baker's dozen consists of thirteen pieces instead of twelve. The idea is that the customer will still have twelve eggs, even with one damaged (and if they are all okay, the thirteenth is a nice bonus). In addition, thirteen eggs fit more efficiently on a baking sheet. Those factors inspired designers to create a space-efficient pack for thirteen eggs. Most packing machines cannot handle this format however so they are only used on a small scale.

Until recently, small eggs were considered second grade. Nowadays, they are marketed as a luxury novel food, which provides added value. For example, you will see 'pullet' eggs in shops – these are the first eggs laid by young hens. Double yolkers are also seen currently as a luxury product, and they sell for higher prices.

Golden egg

You can make a golden egg from an ordinary one by shaking it very hard in its shell. There are special accessories available that make it easier. You can also use a long shirt sleeve to shake the egg content into a mixture while it is still in the shell. Put the egg half way down the sleeve. Fix it in place with a string at each end. Take the two ends of the sleeve in your hands. Swing the sleeve, with the egg in it, a few times around its axis, and then pull the ends sharply outwards. Repeat the process a number of times. Then boil the egg in the normal way. When peeled it will be evenly coloured, light yellow, i.e. a golden egg.

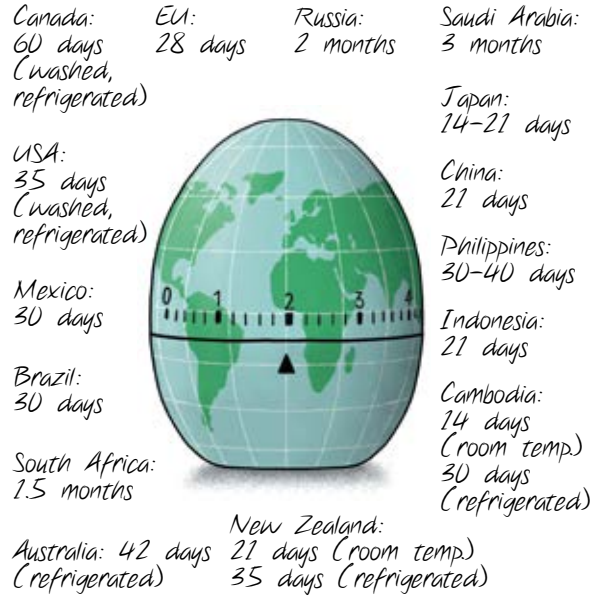
Strange tastes and aromas

Sometimes eggs look absolutely normal but have a strange flavour and odour. The cause is usually a result of incorrect storage and preservation.

Cause	Action
Old eggs	You should store eggs for the shortest period possible to prevent musty odours. Higher temperatures will cause musty odours to occur more quickly. Try to reduce house temperatures as much as possible in summer, and run the egg belts regularly (2 x per day or more)
High storage temperatures	Put the eggs as quickly as possible into a cool space at 12 - 15°C
Poor storage conditions	Eggs will pick up aromas quickly from the surrounding environment. These odours include a fishy smell, sour milk, strong smelling fruit, disinfectants, and poultry manure.
Feed composition	Sometimes, unwanted aromas and flavours come from certain feed ingredients, e.g. poor quality fish or fish oil, vegetables such as onions, root crops and brassicas.
Microorganism	Sometimes, an egg is contaminated with bacteria or moulds, either on the inside or the outside, without a visible sign that anything is wrong with it. Prevent egg contamination store them well, and ensure that they are as clean and fresh as possible.
Hen-related	Some hens will continue, obstinately, to lay abnormal eggs, despite all your preventive measures. Those hens should be culled, even though they might be hard to track down.

What is fresh?

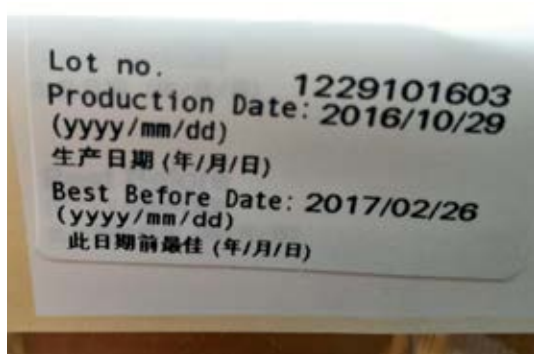
Keeping an egg fresh as long as possible is an art. Every egg has bacteria on its shell, which can reproduce very quickly under warm and moist conditions. That is why it is essential to keep eggs cool and dry. An egg stored this way is still safe and good to eat even after fifty days. Maximum shelf life varies between countries. This is often associated with processing (e.g. washing or oiling), storage conditions (refrigeration), and the regional climate. EU regulations require a best before date of 28 days from laying. In China, the official minimum shelf life period is 21 days, but eggs not sold within fourteen days are often returned to the producer, and then go for processing. Indonesia adheres to 21 days for consumer eggs. In practice, ninety per cent of eggs sell immediately or at least within fourteen days. In Japan, the permitted shelf life varies with the seasons.



The definition of a fresh egg varies in different countries. In Saudi Arabia, and egg is considered fresh as long as it is no older than three months. But they must be regularly turned.

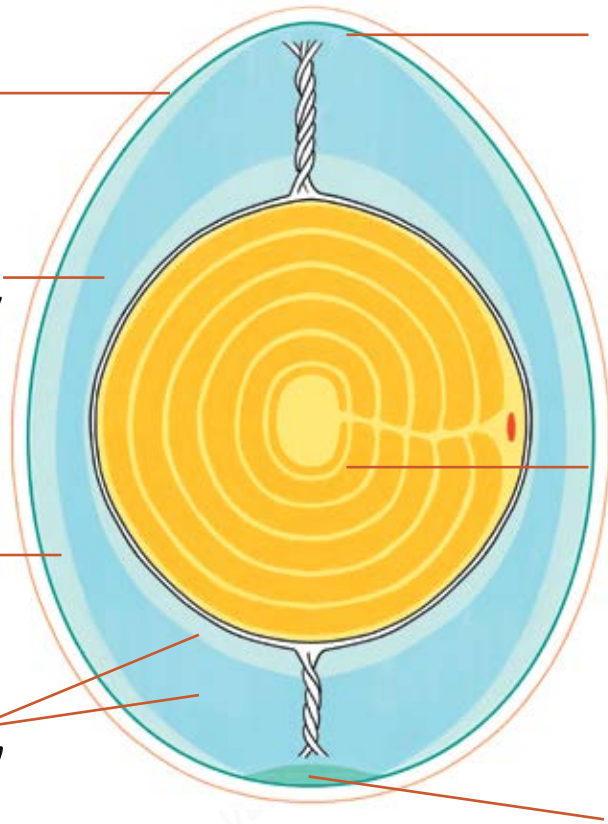
An egg is called fresh up to four weeks from the time it was laid. This also corresponds to the 'best before' date. You can actually keep an egg quite a lot longer, even three to six months.

You will see the following on egg boxes: 'Keep cool after purchase'. That is not actually necessary in a temperate climate. If the eggs are unwashed! The one thing that you must avoid is storing eggs in a refrigerator and then moving them to warmer conditions. Temperature differences and variations in RH lead to loss of quality.



The shelf life in Hong Kong is actually four months, as shown in this picture. There are 120 days between the laying and sell-by dates.

What changes in an egg as it gets older?



Whole egg – weight loss, lower density, different odour. Yet the chemical composition does not change much at all.

Eggshell – less shiny, colours differently under UV-light and sometimes stains appear.

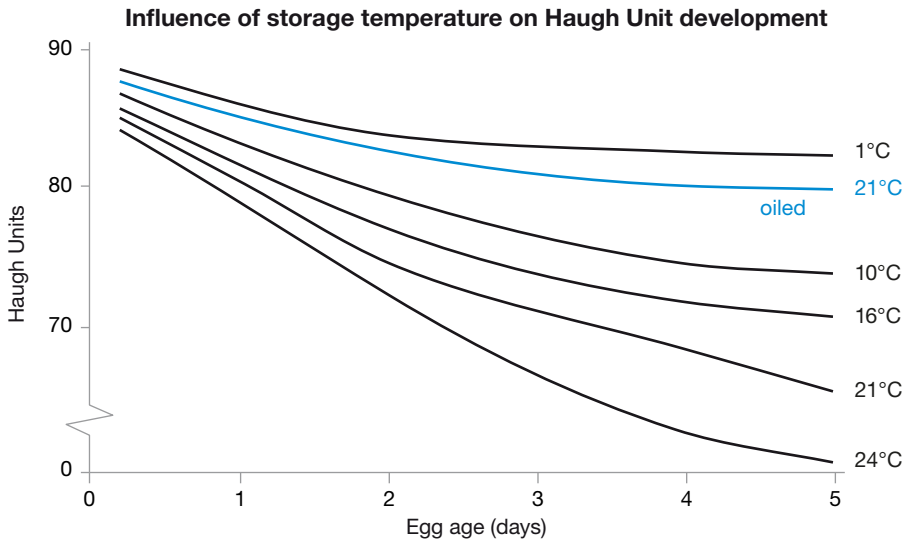
The egg white – loses carbon dioxide and water. The pH increases. The freezing point rises. The coagulant content in the egg white reduces.

Egg yolk – increased water content. Firstly, its volume increases, but it decreases later. The yolk membrane becomes weaker, and the colour deepens. The pH increases. The freezing point drops. The ammonia content increases. The yolk's coagulant content reduces. Free fatty acid levels increase.

Outer thin albumen – water evaporates through the shell.

The thick and inner thin albumen lose water to the yolk.

Air chamber – gains volume.



The storage temperature has a big influence on the Haugh Units.

Eggs in slaked lime

In the past, people used a variety of ways to preserve eggs for use during the winter period, when their hens did not lay any eggs. One method was dusting them in slaked lime (calcium hydroxide). Storage in liquid glass (sodium silicate) was another method.

Source: Optimum Egg Quality, 2007

Storage and the air chamber

The air chamber expands most rapidly with a high temperature and low air humidity. There is less evaporation at lower temperatures, and relatively high air humidity will also limit evaporation. The maximum evaporation rate is 0.1 g of water per day. Although there are approximately 10,000 pores in the shell, they are so tiny that more evaporation than this is virtually impossible.

2°C and 80% RH are ideal

A storage temperature of 2°C and 80% relative humidity (RH) are the optimum conditions for storing eggs for extended periods of time. You can keep eggs for months in such conditions. In comparison, an average domestic refrigerator has a temperature of 5°C and an RH of between 20 and 40%.

It is best to keep eggs in a refrigerator. The lower temperature inhibits bacterial growth and less moisture is lost from the egg. An egg can lose as much quality in one day at room temperature as it will after four days in a refrigerator.

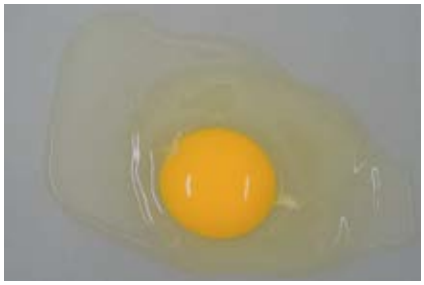
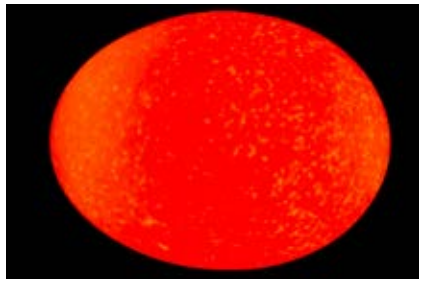
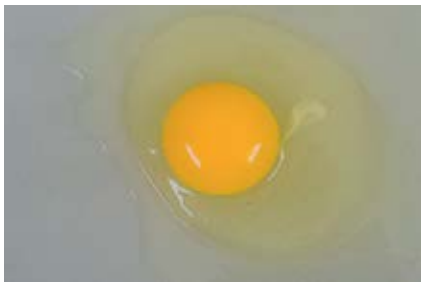
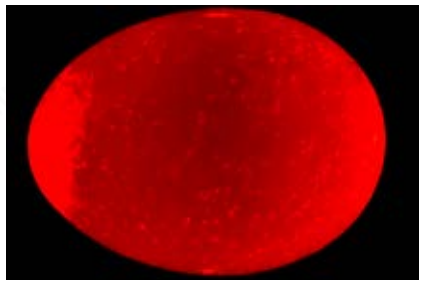
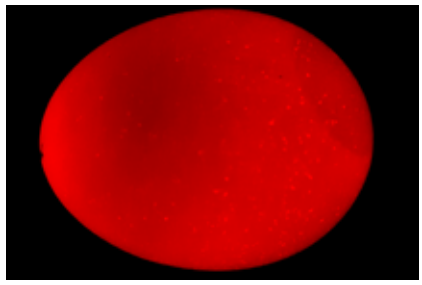
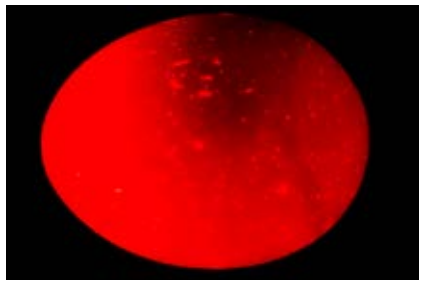
LOOK-THINK-ACT

Is the fridge door the best place to keep eggs?

The door opens and closes regularly, causing continuous temperature variations, which obviously make it a poor choice for egg storage. There is also a greater risk of damage and agitating the contents. It is best to put the eggs, in their box, on a fixed shelf in the fridge. A cardboard box will protect them from damage and stop absorption of odours from strong smelling foods.

Determining freshness

A fresh egg is shinier, and has a sturdy round yolk and compact thick albumen. If the egg spreads out in the pan when you fry it is not so fresh. The position an intact egg adopts when it submerged in water is another freshness indicator. An older egg will float higher than a fresh egg. The air chamber increases, which makes the specific weight of the egg lower and the egg will float in water. You will also see that the yolk has moved to one side if an old egg is boiled.

Thick white	Specific weight	Air chamber
Fresh egg		
		
2 weeks old		
		
4 weeks old		
		
8 weeks old		
		

An old egg is often still good to eat

You can check if an egg is old by submerging it in water. If it stands upright and floats, it is no longer fresh. But it is often still perfectly edible. When in doubt, break the egg into a bowl and check if the yolk is intact and that it still smells good. In practice, people often think that an egg smells bad, even when it is still fresh!

You will not hear any sound in a newly laid egg when you shake it near to your ear. But you will feel the contents moving backward and forward in an older egg and hear a lumpy slurping sound, because the air chamber has increased in size and the egg white is thinner.

The underwater weight is used as a measurement of egg age in research, but also to estimate shell thickness with very fresh eggs.

A freshly laid egg is much more difficult to peel than a week-old one. That is because the inside of the inner shell membrane is still not very well sealed. That happens a little later. At the time of laying, the membrane fibres are almost bonded to the outer thin albumen.

Sometimes a boiled egg has a greenish yolk. This is the result of a compound created through a reaction between sulphuretted hydrogen (hydrogen sulphide, H_2S) and iron. It creates iron sulphide. This occurs during prolonged cooking, or if the egg is not cooled in cold water immediately after cooking it, (the cooking process continues inside the egg). The green discolouration does not damage health and does not have any connection with freshness.

Regional preferences

Each country has its own preferences for the ideal egg: yolk or shell colour, type of egg, fertilized or not, and the acceptable duration of storage.

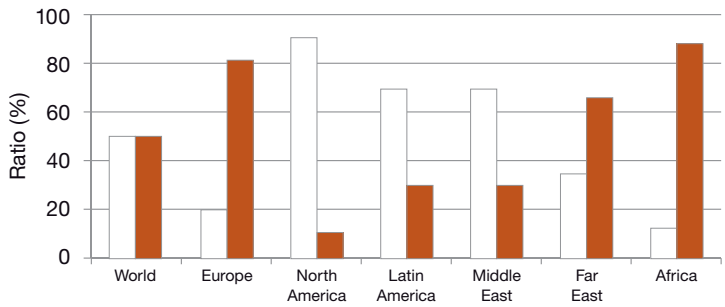
Yolk colour preferences

The most popular yolk colour in the Netherlands is between 8 and 12 on the colour chart. The Germans prefer a colour between 11 and 12. The preferred colour for organic eggs is between 6 and 7. The global preference for yolk colour is between 10 and 11.

Shell colour preferences

Some consumers are convinced that the shell colour influences flavour. They consider brown eggs tastier and more natural than white ones. The brown egg is the favourite in the Netherlands, Great Britain, France, and Spain. But the Scandinavians still prefer white eggs, which are the preference in the USA too. You mainly see white eggs in German supermarkets, but there is a significant market share (25%) in direct sales to consumers at home or through weekly markets, where brown is in fact the egg of choice.

Brown and white eggs in the world



The ratio brown eggs and white eggs in various parts of the world represent the consumer's preferences in those countries.

Traditional egg recipes

Eggs benedict
An American brunch or breakfast dish – an English muffin with poached eggs and bacon under a covering of Hollandaise sauce.

Huevos Rancheros
A Mexican breakfast dish, comprising poached eggs with beans and a salsa, served on a warm tortilla.

Tamagoyaki
A Japanese dish, which comprises multiple layers of omelette rolled together and then grilled.

Scotch eggs
A Scottish picnic dish, made of a hard-boiled egg wrapped in sausage meat.

Choice of table eggs

There are many different types of eggs for sale in shops: cage eggs (no longer allowed in the EU), aviary eggs, free-range eggs, EKO eggs, corn eggs, organic eggs, green Araucana eggs and so on. According to Jewish dietary laws, an egg is only kosher (a ritually permitted foodstuff) if it is totally free of any blood. You can see blood if its present by shining a powerful lamp through the egg (candling). The preference for kosher eggs is for white eggs, because brown shells are harder to see through. In India, consumers prefer cage eggs to ensure they are not fertilised. In Japan and China, pink eggs sell for a higher price than brown or white ones. Eggs from Silkie hens even sell for up to thirty times the price of a regular egg!

In Japan, eggs are often served raw over noodles, and people want to see them sitting firmly in place. This is the reason why the Japanese prefer a stiff thick albumen, in addition to the fact that it is a good sign of freshness. There have even been special strains of chicken developed for Japan, with a genetic predisposition for producing eggs with high Haugh Units (the measurement for thick albumen).

'Thousand year eggs' or 'century eggs' are preserved in a mixture of clay, ash, salt, rice husks, and lime for years before they are eaten. These eggs are a Chinese delicacy. Over time yolk becomes creamy and gets a greenish colour. The egg white becomes transparent brown with a salty flavour and a powerful aroma. It has the texture of a jelly pudding when chewed. Sometimes beautiful salt crystals form on the outside of these eggs. The name 'thousand year egg' is a slight exaggeration because they are mostly stored for around one hundred days.

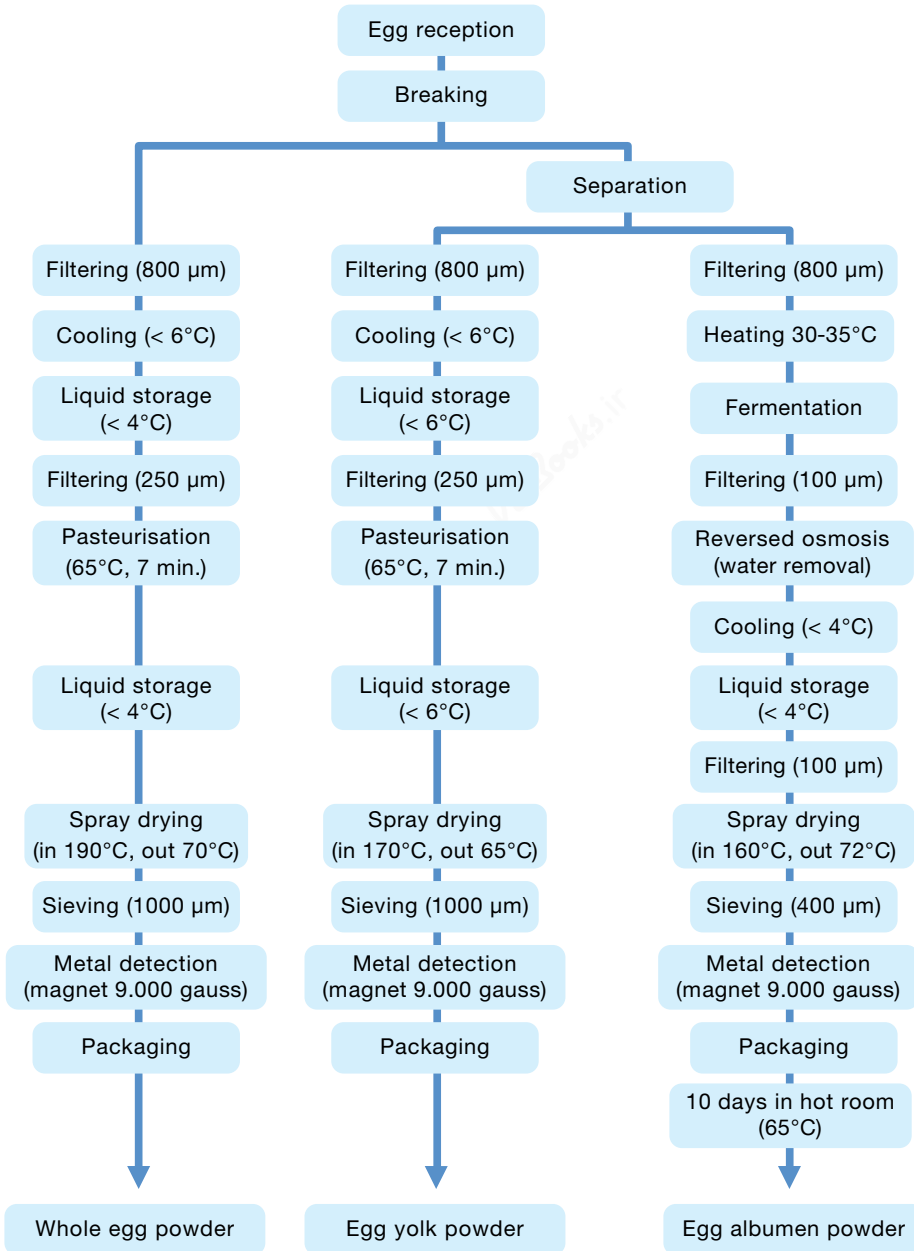
A fertilised chicken or duck egg (balut) is a real delicacy in the Philippines. There is an embryo in the egg, complete with feathers, bones and a beak. Thus, you eat the unborn chicken. People say that eating a balut increases potency. The egg is first boiled and then spooned out. This savoury snack is sold mainly on the streets in the evenings. Reportedly, the high protein content goes beautifully with beer.

Egg processing

On a world-wide basis, 15 to 20% of eggs go for processing. In the EU and USA, this is about 30%. In China, about 5% of eggs are destined for processing and in developing countries, 1 or 2%. There is a variety of egg products, both in liquid and solid forms. These products are used to supply various users such as bakeries, baby food companies, potato and meat processors, and producers of ice cream, salads, pastas, shampoos, mayonnaise, beverages, pies, sauces etc.

Some processed egg products are:

1. Pasteurised and homogenised whole eggs (liquid or powder)
2. Pasteurised and homogenised egg yolks (liquid or powder)
3. Egg white, unpasteurised, or pasteurised (liquid or powder)
4. Lysozyme (extracted from egg white)
5. Eggshell, heat treated and dried



More and more for consumers

Processed egg products are not only for industrial use. The egg industry is responding increasingly to the trend for convenience foods. Western supermarkets are offering an increasing number of ready-to-use, value-added products, e.g. packs of liquid pasteurised egg white, yolk or a mix of the two. These often sell at premium prices!

In South Korea boiled eggs are sold in the stores, packaged per three pieces. This trend towards convenience food is also prevalent in other countries.

Eggshell and plastics

Eggshells are made of calcium carbonate, a substance also used as filler in plastics. Polypropylene plastic costs € 3,000 per tonne. Working 30-40% eggshell into the manufacture of plastics can save a small fortune pretty quickly. Eggshells are a good source of chondroitin, which helps prevent osteoporosis. Eggshell is also good for preventing tooth cavities, and is used in toothpaste.

One uses of eggshells is to raise the pH in acidic soils. Many other sources of calcium have quick action but also deplete quickly. Eggshell derived calcium carbonate works slowly but increases pH for a longer period. It is also a relatively cheap source of calcium carbonate.

In front egg yolk and egg white in powder form. Next to the egg: whole egg powder.

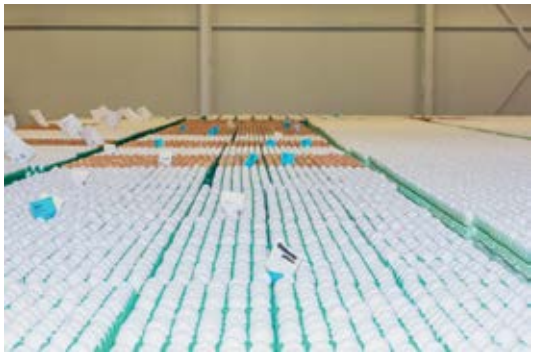
Whole egg, egg white, and egg yolk in liquid form.

Quality requirements eggs

Quality requirements aim at product quality, strict biosecurity, and hygiene (food safety) throughout the production chain i.e. during production, packaging, and transport. They focus on:

- The characteristics of the egg (no damage, correct air chamber size, Haugh Units, yolk and egg white quality, the absence of pathogens, abnormal substances or odours)
- Packaging and transport
- Delivery and coding (traceability)

Besides inspection on delivery, egg products are checked before shipping. These include tests for pH, moisture, fat, protein, lactic and butyric acid content. The bacteriologic composition is also assessed. Sometimes, there are tests for the albumen foaming ability, and salt or ash content.



Eggs are stored in refrigeration units at a 5-8°C prior to being processed.

The pallets are put in position for the conveyor-loading robot. Every poultry farm uses a different colour combination of trays and pallets.

The egg supply

Eggs for processing can come from a variety of husbandry systems. Hygiene on supplier farms is of the utmost importance. Often, eggs for processing are white eggs. These have the best composition with the lowest number of abnormalities. Hens that lay white eggs have good feed conversion rates, and even lay some more eggs. Besides eggs from specialised producers, all second grade go for processing.

Eggs are sent from the poultry farm to the processing plant daily.

The loading robot takes eggs in layers of six trays from the pallets and puts them on the conveyor.

Yolk-white separation

Hygiene in the plant is of utmost importance. The quality manager is responsible for ensuring this. The yolk white separation area must be very clean. Even the employees wear special clean clothes and hats to cover their hair.

A normal conveyor belt can take eggs up to higher levels but it takes a lot of space (left). A carousel conveyor can achieve the same in a lot less space (right).

On arrival the eggs are checked for freshness, cracks, and shell cleanliness. Then conical suction pads take them from the tray and put them on the roller conveyor.

The eggs are laid down in the right direction for dropping onto the breaking knives.

Yolk, egg white, and eggshell are separated. The yolk drops onto a spoon and the albumen into a container below. A camera system checks for egg yolk contamination in the white. If there is any, it is processed with whole egg so that it does not contaminate the egg white products.

A transport auger takes the eggshells with shell membrane away to be centrifuged, heated, and dried ready for use as a calcium source for animal feed or calcium fertiliser for agricultural land.

Liquid products

Egg yolk, white, and whole egg are filtered, heated, and fermented, and they can be pasteurised. Pressurised homogenization to prevent sedimentation is also important. Salt or sugar can be added. Then the product is pumped to the appropriate refrigeration unit. The finished product is shipped out in isotherm tanker trucks or in smaller units.

Lysozyme

Lysozyme is an antibiotic substance found in egg white. A resin is used to extract lysozyme from egg white. It is then used in various ways, including the pharmaceutical and food industries. It is used as an antimicrobial enzyme in wine and cheese production and in the meat industry.

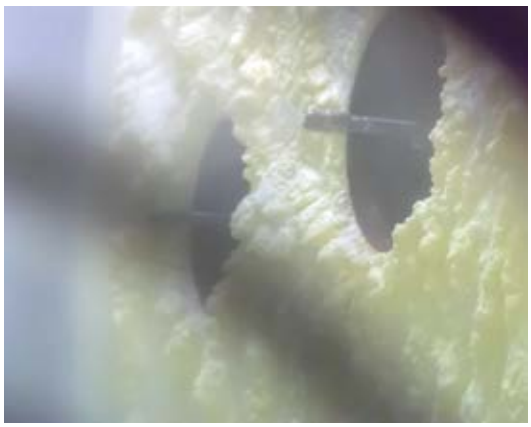
Egg white powder

There are three types of egg white powder:

1. standard
2. high whip (high foaming ability)
3. high gel (binding protein for meat processors)

Standard egg white is produced with plate or spray drying. Before the egg white runs through the sprayer, it is filtered, subjected to reverse osmosis, has citric acid added to lower the pH, and, after temporary storage at a temperature below 4°C, it is filtered once more. Then the product goes through a sieve.

High whip egg powder and high protein gel is produced under changing moisture, temperature, and pH conditions.



Spray drying is done in a large horizontal tank.

Egg powder is put in Big Bags (left), or in 25-kg plastic bags, which are then put in cardboard boxes (bag-in-box).

Eggs can be pasteurised whilst in the shell and still stay liquid.

Viewing points in the pipework allow you to see which product is pumping through, whole egg, yolk, or egg white.

Boiled and peeled eggs

There are ready-to-use boiled and peeled eggs available for the catering industry. These convenience products eliminate the need for boiling eggs, and speeds up work.

1. *The eggs get a tap, to prevent cracks during boiling. This has the same effect as when people prick a hole in the air chamber end of an egg before boiling it.*

2. *They come out of the boiling machine. Not every egg remains intact, thus there is some egg white on the roll away plate.*

3. *They are cooled with water to make the job easy in the peeling unit. And that rinses off any loose yolk and egg white.*

4. *After peeling, the peeled eggs go into a large bath to wash off any remaining eggshell fragments.*

Egg Roll

An egg part ideally has a yellow core surrounded by white. Therefore the end parts of the egg are less desired. The solution: the Egg Roll. You can cut 42 equal sized slices out of one roll. And you can use this whole egg product right down to the last slice. Very handy for the convenience food market.

Peeled eggs like these are sold to the catering industry (left) and to the consumer (right).

Index

Solution of test on page 11

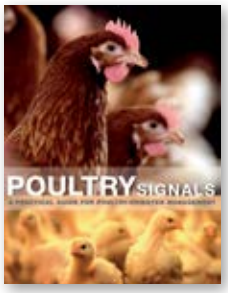
A - 2
B - 3
C - 1

Roodbont Publishers

Roodbont Publishers considers its core business to be supporting agriculturalists by providing the right information at the right time. Agricultural publications from Roodbont can be ordered from bookstores or direct from Roodbont, tel. +31 575 54 56 88, e-mail: info@roodbont.com or from the website: **www.roodbont.com**.

Language editions:

Check availability of various language editions via **www.roodbont.com**.

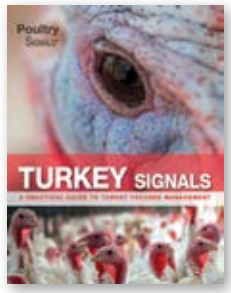


POULTRY SIGNALS

A practical guide to bird focused poultry farming

Proper management starts with recognising signals in practice. This means being alert, watching, listening, and paying attention to their behaviour. This provides much information about animals' health, well-being and production.

ISBN 978-90-8740-079-8
112 pages, 20.5 x 26.5 cm

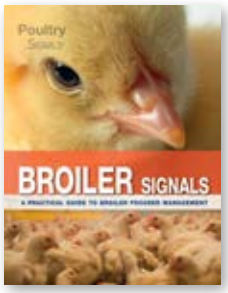


TURKEY SIGNALS

A practical guide to turkey focused management

On a global scale, turkey production volumes are relatively stable. Efficiency improvement is the main challenge for every turkey farmer. *Turkey Signals* follows the cycle on a commercial turkey farm.

ISBN 978-90-8740-262-4
200 pages, 20.5 x 26.5 cm

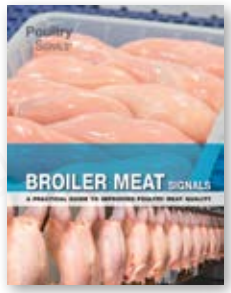


BROILER SIGNALS

A practical guide to broiler focused management

Broilers grow fast in a short time of period. That's top sport and the slightest disturbance can disrupt this delicate process. So you need to quickly respond to signals, but more important is to avoid problems.

ISBN 978-90-8740-125-2
120 pages, 20.5 x 26.5 cm

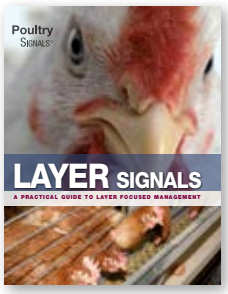


BROILER MEAT SIGNALS

A practical guide to improving poultry meat quality

Broiler Meat Signals contains essential practical information about every step in poultry meat processing with practical tools and modern insights to guarantee an efficiently produced, safe, healthy and tasty product.

ISBN 978-90-8740-330-0
192 pages, 20.5 x 26.5 cm

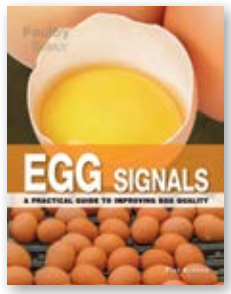


LAYER SIGNALS

A practical guide to layer focused management

Kept in cage or floor systems, for a good performance during the production period, the management must be on point. This edition focuses purely on layers with a great deal of attention paid to breeding and egg quality.

ISBN 978-90-8740-124-5
120 pages, 20.5 x 26.5 cm



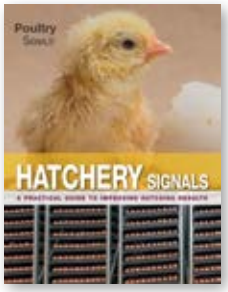
EGG SIGNALS

A practical guide to improving egg quality

Egg Signals follows the egg's progress through all the links in the chain, from poultry farmer to packer, processor, and consumer. It describes the creation of the egg's unique composition.

ISBN 978-90-8740-272-3
164 pages, 20.5 x 26.5 cm

EXPECTED:



HATCHERY SIGNALS

Hatchery Signals explains all factors that affect hatchability and chick quality. It provides guidelines and advice on how to improve offspring performance with new developments and innovations. A must have for everybody involved in hatcheries.

ROODBONT
AGRICULTURAL PUBLISHERS

For more information about these and other Roodbont publications please check our website:
www.roodbont.com

Poultry
SIGNALS©

EGG SIGNALS

A practical guide to improving egg quality

'Managing egg quality requires keeping an eye on the details.'

Egg Signals follows the egg's progress through all the links in the chain, from poultry farmer to packer, processor, and consumer. It describes the creation of the egg's unique composition. Optimising egg quality is one of the most important points in the entire poultry chain. You can certainly influence an egg's quality before the hen lays it, but it is critical to take steps to maintain egg quality after laying as well. Successful professionals know how to manage egg quality, keep it under control, and make decisions based on their production and their flock.

That involves an eye for detail. *Egg Signals* shows you how to develop and train that 'eye'. Regularly ask yourself the following questions: What do I see? What does it mean? What should I do? It will help you to gain firmer insight into the process. In addition, *Egg Signals* provides answers to questions such as these: How are eggs with optimal quality created? What type of hen lays them? How do you prevent abnormalities? How do you add value? Even the position of a crack, for example, can tell you a lot about the cause.

Egg Signals uses 650 photographs and images to illustrate the basis of thinking about quality, and describes how to act accordingly. This book employs real-life cases taken directly from practice, leading to satisfied poultry professionals and happy consumers!

Egg Signals is part of the successful *Poultry Signals*© series. *Poultry Signals*© presents practical knowledge of animal oriented poultry farming in an easy, accessible format.

ROODBONT
AGRICULTURAL PUBLISHERS
www.roodbont.com

ISBN 978-90-8740-272-3
9 789087 402723 >