A message from the author

It is well known that eggs are a natural and nutritious food source. What is less well known is the fact that, as a natural product, no two eggs are ever quite the same. Eggs will show variations in shape, color, yolk, size, as well as other characteristics. These can be influenced by the hen's breed and age, by its feed, and by the climate in which it lives. Furthermore, the quality of each individual egg changes over time. On account of these variations, the subjective evaluation of eggs will vary from person to person. It is the purpose of this book to provide a graphic guide to the wide range of possible egg characteristics and their potential causes, and to provide recommendations for their usage.

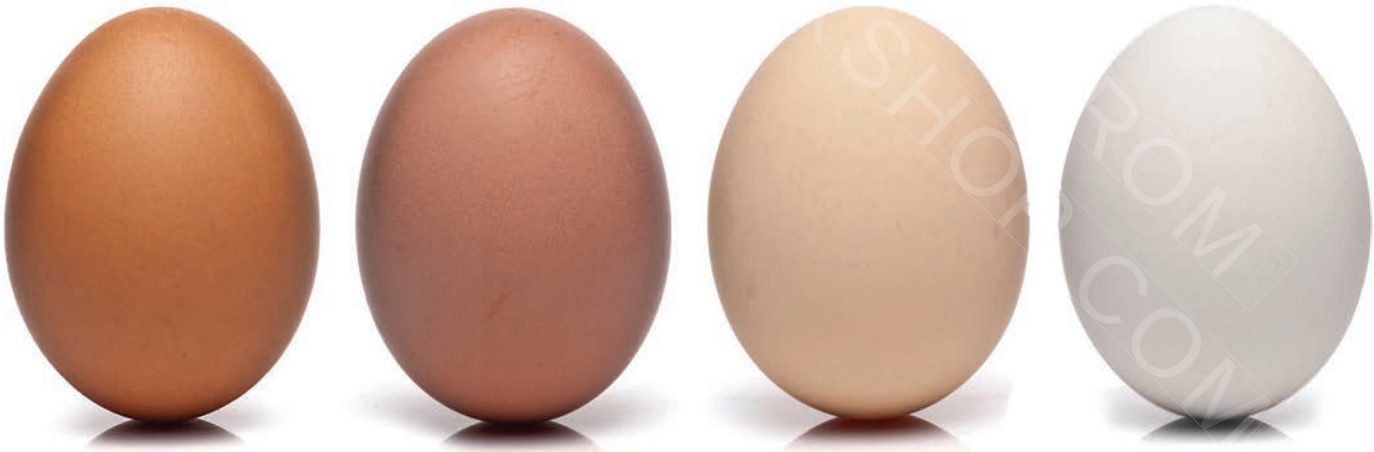
Our company, NABEL Co. Ltd., has developed egg detectors for various egg abnormalities such as shell cracks, dirtiness, blood spots or rottenness. These and more examples have been collected in the course of our technical journey, and were first published in a book that appeared in Japanese in 2009.

Currently, the Japanese edition of this book is utilized as a communication tool aimed at engendering common perceptions among egg producers, retailers, and consumers. We are very pleased that it is also used as an educational tool for new employees, as well as high school and university students.

On the basis of the successful reception of the Japanese edition, it was decided to create an internationally oriented version. For this we were delighted to engage DSM Nutritional Products as a partner to help us not only to translate the text but also to give it a global focus and approach, without losing its Japanese roots.

I hope that this book will stimulate a greater interest in eggs and also contribute to a better understanding of this valuable food source.
Finally, I would like to express my deep appreciation to all those who have supported me with the development and publication of this book.

Ayuko Kashimori
NABEL Co.,Ltd
November 2016



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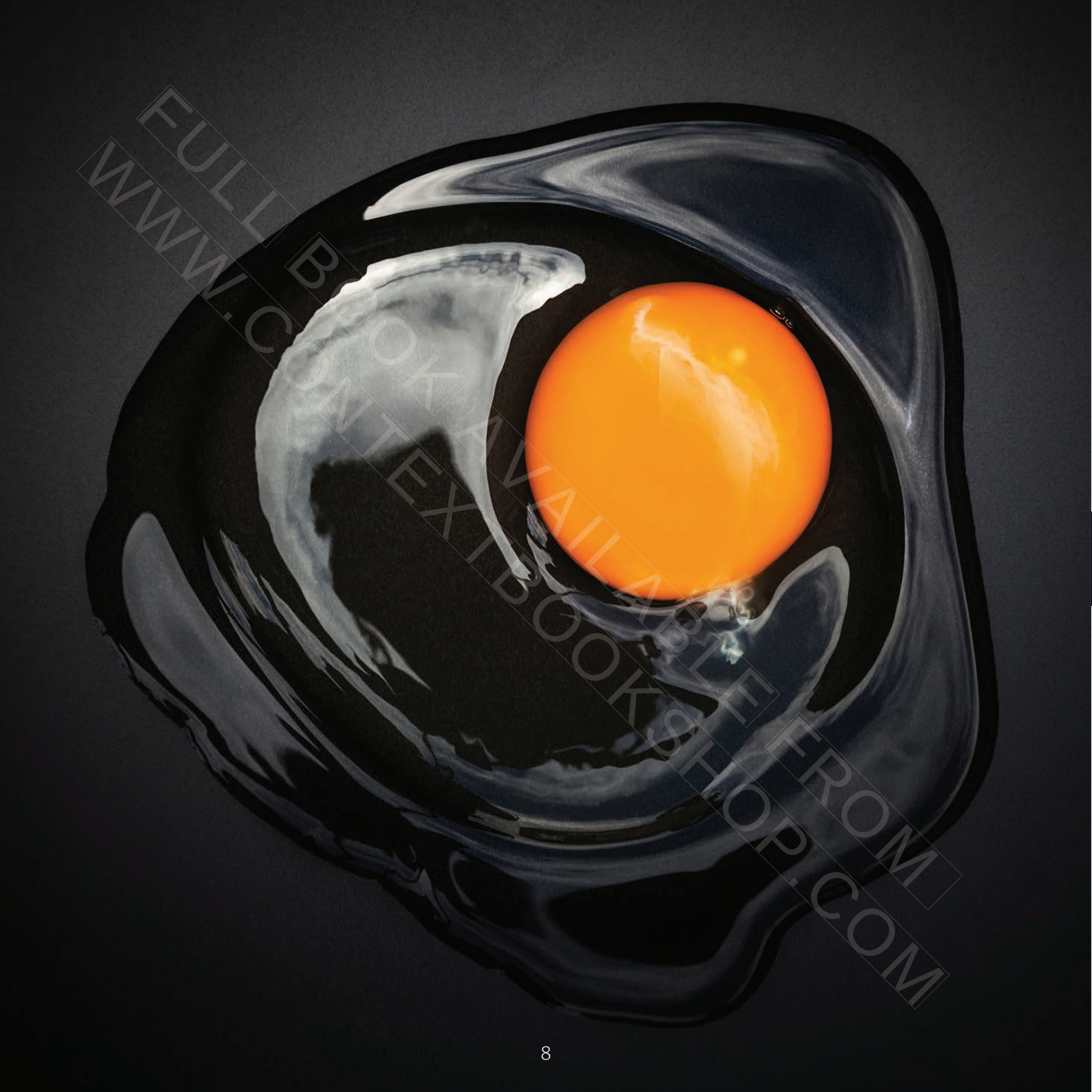
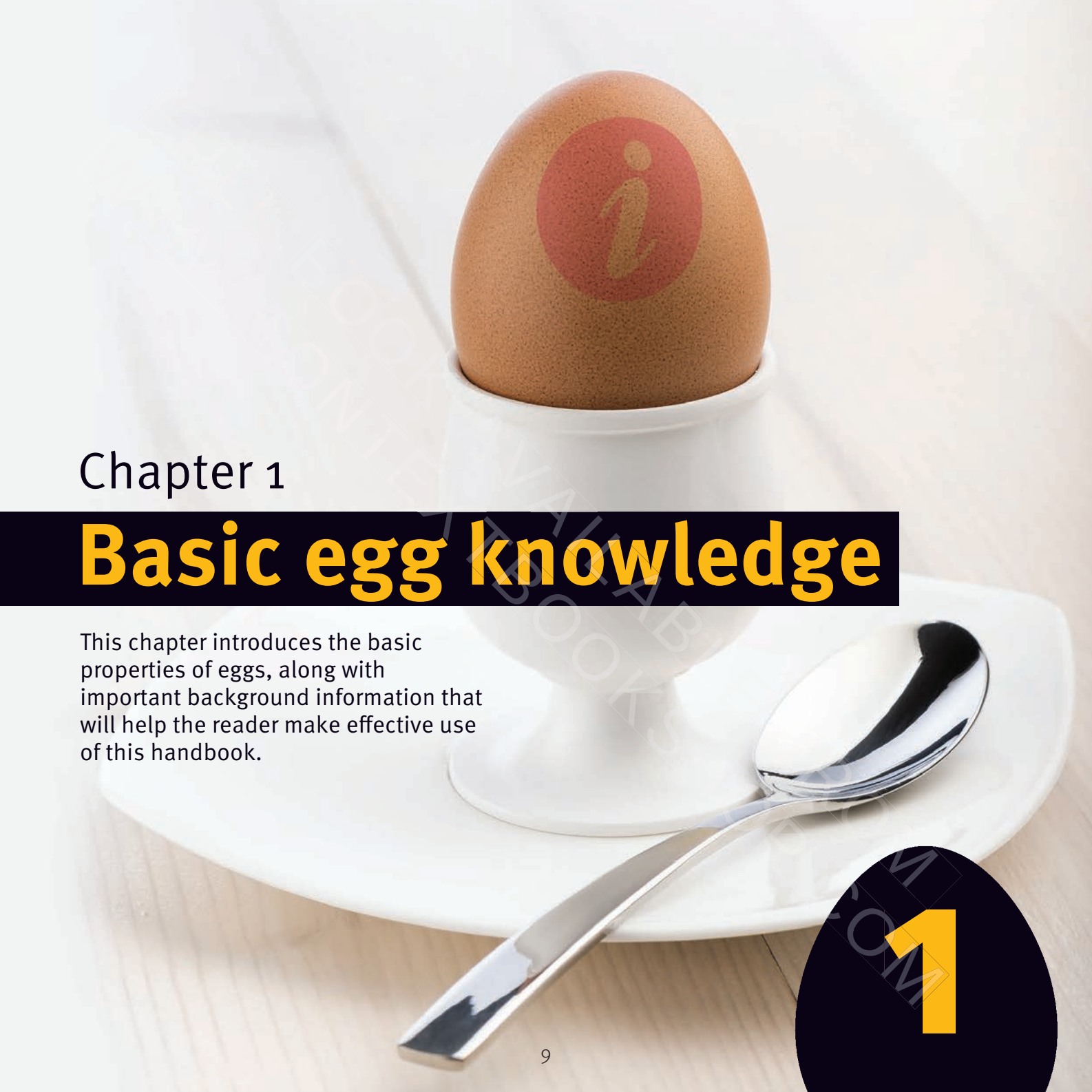




Chapter 1

Basic egg knowledge

This chapter introduces the basic properties of eggs, along with important background information that will help the reader make effective use of this handbook.

1

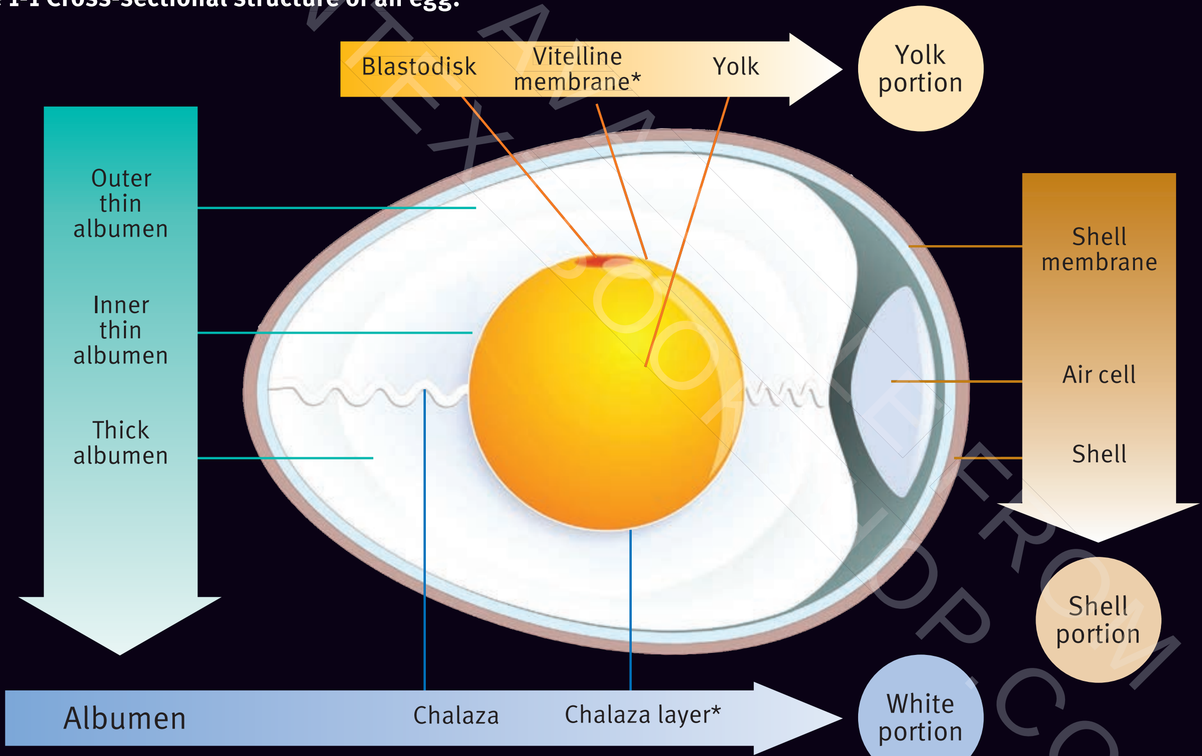
The structure of an egg

Bird eggs exhibit an exceptional tissue structure that serves to prevent physical damage and contamination with microbes from outside the egg. In a fertilized egg from an ovulating chicken, this structure protects the embryo over the approximately three weeks that it takes for the egg to hatch.

Broadly speaking, shell eggs consist of three areas, from the outside in: the shell portion (which includes the shell, shell membrane, and air cell); the white portion (which includes the albumen, chalaza, and chalaza layer); and the yolk portion (which includes the vitelline membrane, blastodisc, and yolk). These areas of the egg exist in a ratio of approximately 1:6:3 by weight.

Figures 1-1 and 1-2 show the roles played by the constituent parts of a typical egg.

Figure 1-1 Cross-sectional structure of an egg.



*The chalaza layer is found outside the vitelline membrane.

Chapter 2

Examples of eggshells

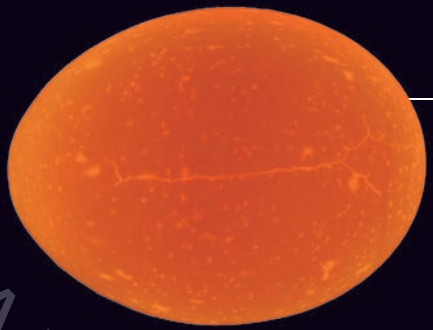
This chapter introduces abnormalities known to affect the shell and outward appearance of eggs, along with examples of complaints and questions received from consumers.

Minor shell breakage

Hairline cracks become evident with the passage of time. In addition to being visualized by candling and applying pressure along the crack, such defects can be detected by means of sound, since cracked eggs emit a low, dull sound if you tap them near a crack, for example with the tip of a fingernail. Cracks that spread out in a spider web-like radial pattern from the point of an impact are usually seen near the equator of the egg.

(1)

A hairline crack in the shape of a horizontal line exists at the equator of this egg's shell but cannot be discerned with the naked eye.



(2)

When egg (1) is candled, the crack can be clearly discerned.

(3)

A spider web-shaped crack has developed at the equator of this egg. Since most of the shell in that area has not collapsed.

(4)

When egg (3) is candled, the crack is clearly discernible.

(5)

The shell of the egg has collapsed around this spider web-shaped crack. It is more visible than egg (3) and can be clearly discerned with the naked eye.

(6)

There is cracking almost all the way around this shell.

This defect is often seen in eggs whose quality has been compromised, for example in thin-shelled eggs.

Chapter 3

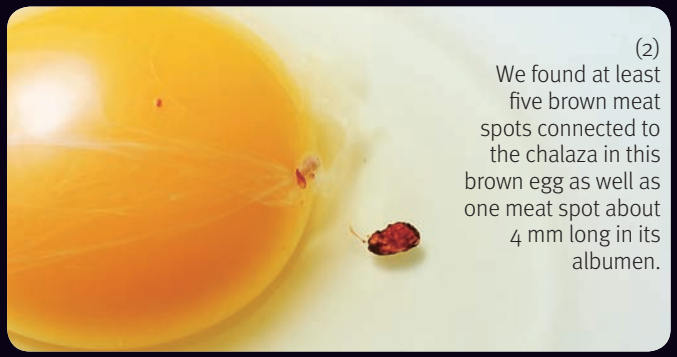
Albumen and yolk

This chapter focuses on quality problems within the egg itself, highlighting a wide range of abnormalities that can affect the yolk, the albumen and the inside of the shell.

Eggs with meat spots

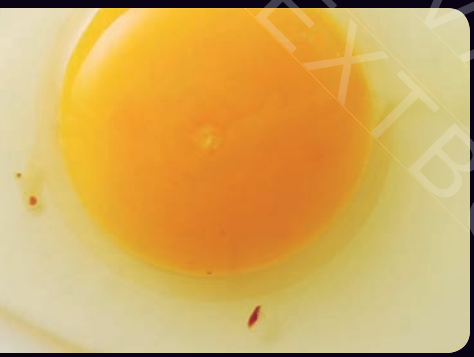
Meat spots are small spots that resemble pieces of wood in the albumen. These range in size from very small to larger than 3 mm in diameter, with eggs exhibiting one or multiple spots.

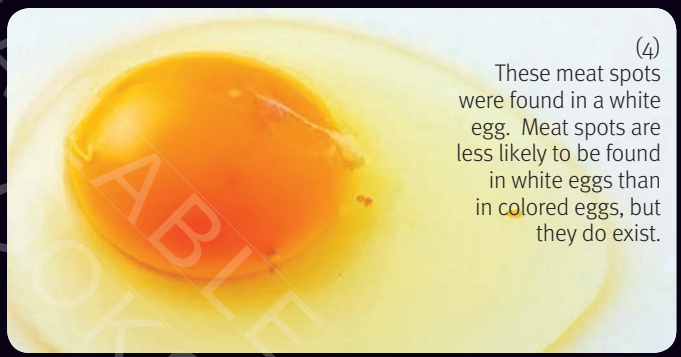
(1)
We found more than 10 brown-colored meat spots, ranging in size from large to small, in this light brown egg. Based on the results of checking them, they are likely to be clumps of the shell pigment protoporphyrin.



(2)
We found at least five brown meat spots connected to the chalaza in this brown egg as well as one meat spot about 4 mm long in its albumen.

(3)
We found four meat spots in the albumen and chalaza of this brown egg that are likely pieces of tissue.





(4)
These meat spots were found in a white egg. Meat spots are less likely to be found in white eggs than in colored eggs, but they do exist.

Background

Meat spots are thought to be particles of the shell pigment protoporphyrin, pieces of the membrane from the yolk surface, or pieces of tissue. Their color varies with shell color, and aging and disease of the hen are known to increase their incidence.

Handling precautions

Eggs may be eaten as long as the inside is not contaminated or rotten. The presence of multiple meat spots may decrease the egg's product value as a shell egg.

Shell color	Incidence of meat spots (%)
White	1.5
Light brown	13.8
Brown	33.1

Results from 24,418 eggs by NABEL, Co., Ltd. 2008.

References: Yasushi Sato (1980). The Study and Use of Eggs, p.138, Chikyusha.
Yoshihisa Yamagami (1984). Egg Quality, pp.38-39, Keiran-Niku Joho Center.
Jeffrey A. C., Graham C. W. (2007). Optimum egg Quality A Practical Approach, p.49, The State of Queensland, Australia and DSM Nutritional Products Ltd.

Notes: The darker the shell color, the more likely meat spots are to be found. In addition, the coloration of meat spots varies with the shell color of the egg in which they are found.

Chapter 4

Examples of boiled eggs

This chapter introduces abnormalities that are seen in boiled eggs, along with examples of complaints and questions received from consumers.

Boiled eggs with green yolks

The yolks of these boiled eggs exhibit color ranging from dark green to black. The discoloration occurs at the surface layer where the yolk and albumen meet but does not extend into the center of the yolk. The yolk will often emit sulfurous odor.

(1)
Left: The yolk of this egg, which was boiled for 30 minutes, has turned green.
Right: The yolk of an egg that was cooled rapidly after being boiled for 12 minutes.

(2)
A cross-section of a yolk that has turned green.
The discoloration can be seen to affect only the surface of the yolk.

Background

Green discoloration of the surface of the yolk is caused when sulfur (S) contained in the albumen and iron (Fe) in the yolk combine to form ferrous sulfide (FeS) where the albumen and yolk meet. The coloring becomes more pronounced the older the egg and the higher the cooking temperature, and it can be prevented by rapidly cooling the egg with cold water immediately after cooking, which has the effect of lowering the pressure in the shell. Carotenoids seem to improve the vitelline membrane strength and reduce the green discoloration of the yolk.

Handling precautions

Eggs with green yolks may be eaten without any problem, since the phenomenon presents no hygienic or safety issues.

References: Yusuke Asano and Ryozo Ishihara (1985). Eggs: Chemistry and Processing Technologies, pp.237241, Korin.
Noriko Ogawa (1998). The Study of Eggs (Ryo Nakamura, ed.), pp.105-108, Asakura Publishing.

Chapter 5

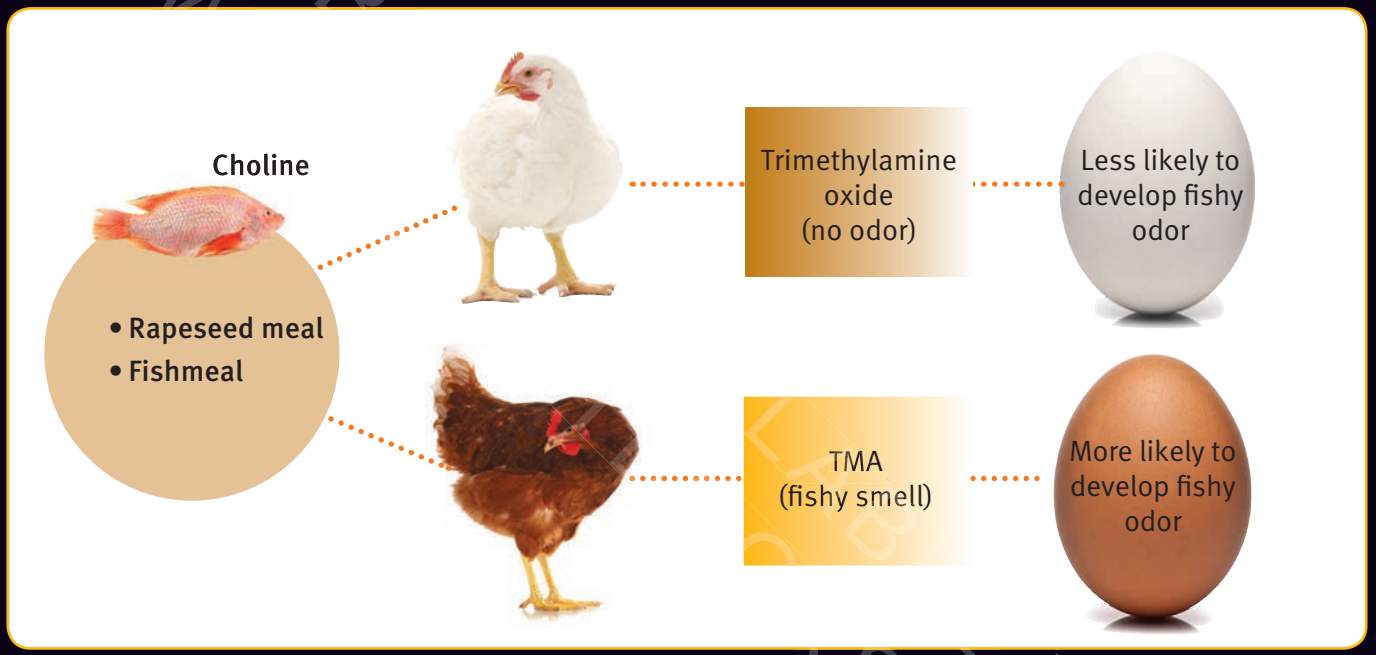
Examples involving odor

This chapter introduces examples of complaints and questions received from consumers involving the flavor and odor of raw and boiled eggs.

5

Fishy odor

Eggs in various states of preparation – including raw eggs broken open, eggs in the process of being cooked, and boiled eggs may give off a fishy odor. Although it is extremely rare, eggs giving off a very strong odor may be distinguished by the odor emitted from the shells. Some people perceive a faint fishy odor as being just an egg-like aroma, and people tend to have strong opinions about whether they like or dislike this odor.



Background

It is thought that the fishy odor given off by some brown eggs derives primarily from trimethylamine (TMA). Since brown layers have lower TMA oxidase activity in their livers than white layers, they synthesize TMA in their bodies from fishmeal and rapeseed meal in their feed. It is known that when the concentration of TMA exceeds a certain amount, these hens' eggs give off a fishy smell.

Apart from feed, TMA may be given off by the rotting process in liquid eggs.

Handling precautions

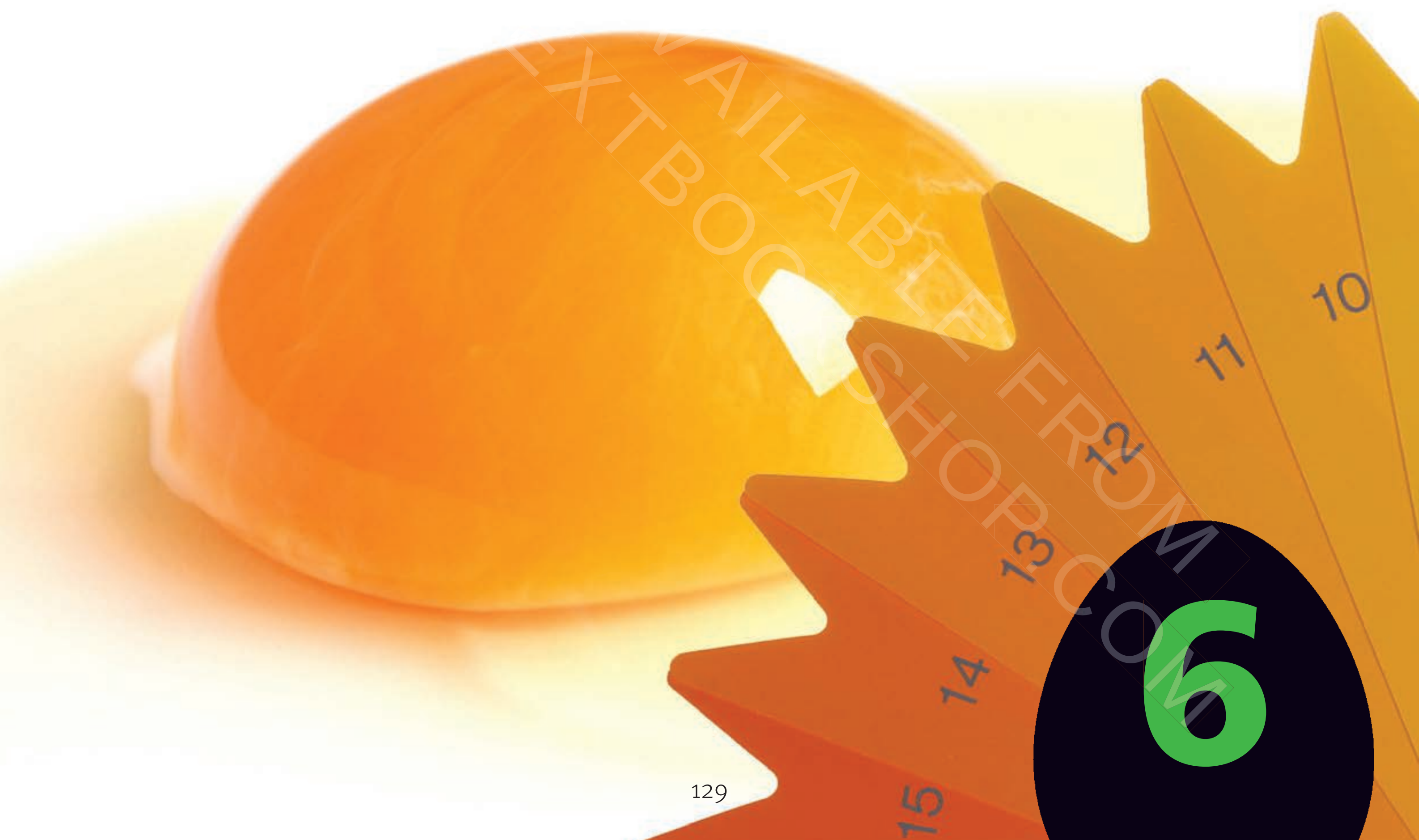
Eggs may be eaten as long as the inside is not contaminated or rotten. Although odor does not reflect any issue with the egg's internal quality, eggs that give off a fishy odor may be perceived as having lower product value as shell eggs if the odor is very strong or if consumers dislike even slight amounts of odor.

References: Yoshihisa Yamagami (1984). Egg Quality, pp.92-94, Keiran-Niku Joho Center.
Chuhei Imai (1983). Chicken Egg Knowledge: The Science of Egg Preservation and Processing, pp.278–283, Food Chemicals Newspaper Inc.

Chapter 6

Egg quality indicators

This chapter introduces egg quality indicators, associated measurement methods, and other data related to quality.

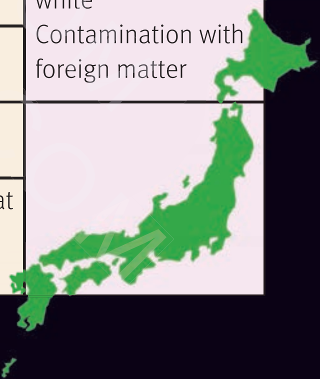


Classifying egg quality (Japan)

The *Egg Standard Transaction Guidelines* (issued as a bulletin by the Administrative Vice-minister of Agriculture, Forestry and Fisheries on December 1, 2000) sets forth a series of standards, called the Egg Transaction Standards, governing egg transactions for shelled and other eggs, including weight categories, labeling methods, and container materials (see "Egg Transaction Standards (Boxed Egg Standards)" on page 141). Similarly, the *Guidelines on Sanitary Management at Egg Grading and Packing Facilities* (issued as Bulletin No. 1674 by the Director-General of the Environmental Health Bureau of the Ministry of Health and Welfare on November 25, 1998) sets forth a series of implementation guidelines for such aspects of industry operations as the storage, washing, packaging, and labeling of shell eggs. This section introduces an overview of those portions of both sets of guidelines that relate to the classification of the quality of shell eggs as outlined in Tables 6-1 and 6-2.

Table 6-1. Overview of quality classifications defined by the ***Egg Transaction Standards.***

		For raw consumption		For cooked consumption	Not for consumption
Grade		Special Grade	Grade 1	Grade 2	Not classified
Shell (appearance inspections, candling)	Shape	Oval	Somewhat distorted	Oddly shaped	Moldy Broken eggs with leakage of egg contents Accompanied by unpleasant odor
	Texture	Fine	Somewhat rough	Very rough Soft shell	
	Color	Normal color	Somewhat faded		
	Presence of dirt	Clean	Minor dirt	Significant dirt	
	Damage	No damage	No damage	Broken but without leakage of egg contents	
Egg contents (Candling)	Yolk	Located in center	Somewhat offset from center Somewhat flattened	Significantly offset from center Flattened and enlarged Scrambled yolk and white (mechanical cause)	Rotten Interrupted incubation Contaminated with blood Scrambled yolk and white Contamination with foreign matter
	White	Not flaccid	Somewhat flaccid	Flaccid and liquefied	
	Air cell	Depth of 4 mm or less. Uniform	Depth of 8 mm or less. Slight movement	Depth of 8 mm or more Significantly offset	
Egg contents (Inspection after breaking)	Yolk	Round with good height	Somewhat flattened	Flattened with flaccid vitelline membrane	
	White	Mostly thick albumen with good height	Small amount of thick albumen, flattened	Mostly thin albumen that is spread out	



Appendix

Egg transaction standards (Boxed egg standards for Japan)

Egg Standard Transaction Guidelines (issued as Bulletin 12-Livestock-A-3266 by the Administrative Vice-Minister of Agriculture, Forestry and Fisheries on December 1, 2000)

1. Eggs are classified into LL, L, M, MS, S, and SS categories based on the following standards:

Category	Standard
LL	Boxes containing eggs whose weight is greater than or equal to 70 grams but less than 76 grams
L	Boxes containing eggs whose weight is greater than or equal to 64 grams but less than 70 grams
M	Boxes containing eggs whose weight is greater than or equal to 58 grams but less than 64 grams
MS	Boxes containing eggs whose weight is greater than or equal to 52 grams but less than 58 grams
S	Boxes containing eggs whose weight is greater than or equal to 46 grams but less than 52 grams
SS	Boxes containing eggs whose weight is greater than or equal to 40 grams but less than 46 grams

2. Eggs in each category are classified as Special Grade, Grade 1, and Grade 2 based on the following standards:

<table>
<tr><td colspan="2" rowspan="2">Grade and quality</td><td>Special grade</td><td>Grade 1</td><td>Grade 2</td></tr>
<tr><td>At least 80% of the eggs in the box exhibit Special Grade quality, and other eggs exhibit Grade 1 quality.</td><td>At least 80% of the eggs in the box exhibit Special Grade quality, and other eggs exhibit Grade 1 quality.</td><td>All eggs in the box exhibit Grade 2 quality or higher.</td></tr>
<tr><td colspan="2">Net weight</td><td colspan="3">10g</td></tr>
<tr><td rowspan="2">Container material</td><td>Outer</td><td colspan="3">Boxes shall be made of cardboard and exhibit JIS Class 1 breakage strength of at least 8.8. They must either be new or be clean and free of any defects in outward appearance.</td></tr>
<tr><td>Inner</td><td colspan="3">Packaging must be clean, elastic, and strong, and it must cushion eggs individually.</td></tr>
<tr><td rowspan="4">Container dimentions</td><td>Outside length / Type</td><td>Depth (cm)</td><td>Length (cm)</td><td>Height (cm)</td></tr>
<tr><td>4A</td><td>50.0</td><td>46.0</td><td>49.0</td></tr>
<tr><td>4B</td><td>25.0</td><td>30.0</td><td>30.5</td></tr>
<tr><td>3</td><td>27.0</td><td>23.0</td><td>21.5</td></tr>
</table>

Remarks
1. If used boxes are utilized as outer packaging, they must bear the unique trademark of the shipper.
2. Inner packaging may consist of either a flat or tray design.

Note

(1) The quality of individual eggs shall be classified as Special Grade, Grade 1, Grade 2, or off-grade as described below based on the condition of each part of the egg as ascertained by visual inspection, candling, or inspection after breaking the egg. This determination shall be made by normal visual inspection and candling, and inspection after breaking the egg shall be used when it is difficult to make a determination by means of candling.

Item \ Grade		Special Grade (for raw consumption)	Grade 1 (for raw consumption)	Grade 2 (for cooked processing)	Off-grade (unfit for consumption)
Visual inspection and candling	Shell	Eggs with a shell that is oval and thick with fine texture Eggs with normal color Eggs with a clean, undamaged shell	Eggs with a shell that exhibits minor defects, for example abnormal shape, rough texture, or faded color Eggs that are undamaged and exhibit only minor contamination	Eggs with abnormally shaped shells Eggs with markedly rough shells Eggs with soft shells Eggs with serious contamination Broken eggs with no leakage of egg contents	Moldy eggs Broken eggs with leakage of egg contents Eggs that emit an unpleasant odor
Candling	Yolk	Eggs with a yolk that is located in the center of the egg with a slightly visible outline Eggs whose yolk does not exhibit flattening	Eggs with a yolk that is slightly offset from the center of the egg Eggs whose yolk exhibits a clear outline Eggs whose yolk exhibits slight flattening	Eggs with a yolk that is significantly offset from the center Eggs with a yolk that is flattened and enlarged Eggs whose white and yolk have been scrambled due to mechanical stress	Rotten eggs Partially incubated eggs Eggs with blood contamination Eggs whose white and yolk have been scrambled Eggs contaminated with foreign matter
	White	Eggs with a white that is transparent and not flaccid	Eggs with a white that is clear but exhibits slight flaccidity	Eggs with a white that exhibits flaccidity and liquid consistency	
	Air cell	Eggs with an air cell that is mostly stable with a depth of 4 mm or less	Eggs with an air cell that has depth of 8 mm or less and that moves slightly	Eggs with an air cell that has depth of greater than 8 mm and that moves significantly	
Inspection after breaking the egg	Diffusion area	Eggs whose diffusion area is small	Eggs whose diffusion area is normal	Eggs whose diffusion area is significantly large	
	Yolk	Eggs with a yolk that is round and exhibits good height	Eggs with a yolk that exhibits slight flattening	Eggs with a yolk that exhibits flattening and a weak vitelline membrane	
	Thick albumen	Eggs whose thick albumen accounts for most of the albumen, exhibits good height, and surrounds the yolk entirely	Eggs with little thick albumen and whose thick albumen is flat and does not adequately surround the yolk	Eggs with little thick albumen	
	Thin albumen	Eggs with little thin albumen	Eggs with a normal amount of thin albumen	Eggs that consist mostly of thin albumen	

Remarks

A. Grade 1 eggs exhibiting minor contamination are dirty eggs (eggs whose shells are contaminated with feces, blood, egg contents, feathers, or other material) that can be cleaned so that no dirt (or only marks left by the dirt) remains after washing.
B. Grade 2 soft eggs have a robust shell membrane but have defects in the shell or a thin shell.
C. Grade 2 eggs with serious contamination have dirt that remains even after washing.
D. Grade 2 broken eggs include:
(1) Eggs with cracks that are discovered during candling, (2) Eggs with a broken shell but a normal shell membrane, (3) Eggs with a broken shell and a ruptured shell membrane
E. Off-grade broken eggs have a ruptured shell membrane and exhibit leakage of egg contents.
F. Off-grade blood eggs are contaminated with a large amount of blood that can be perceived with the naked eye (for example, eggs that contain congealed blood or have a large amount of blood diffused throughout the white). However, eggs that contain only a small amount of blood the size of a grain of rice are called 'eggs with blood spots' and differ from off-grade blood eggs.
G. Off-grade eggs whose white and yolk have been scrambled have a ruptured yolk. However, this category does not include eggs whose yolk ruptured due to mechanical stress.
H. Because it is more difficult to check the condition of the contents of colored eggs than white eggs by candling, producers of the former are required to take steps such as slowing the passage of eggs through the inspection device and increasing the precision of the inspection process.
I. With the exception of the provisions concerning the air cell, the judgment standards that define grade categories are intended to ensure fairness in grading by standardizing how inspectors look at eggs, for example through the definition of reference samples.
J. Because it is difficult to actually measure the depth of the air cell, judgment relies on the visual estimation of inspectors, who must be trained. Air cells also may be located on the side of the egg, in which case they shall be judged in the same manner as applies when they are positioned normally.
K. Blood eggs, eggs contaminated with foreign matter, and other defective eggs can only be identified by means of candling. Consequently, candling must be performed as part of the grading process.