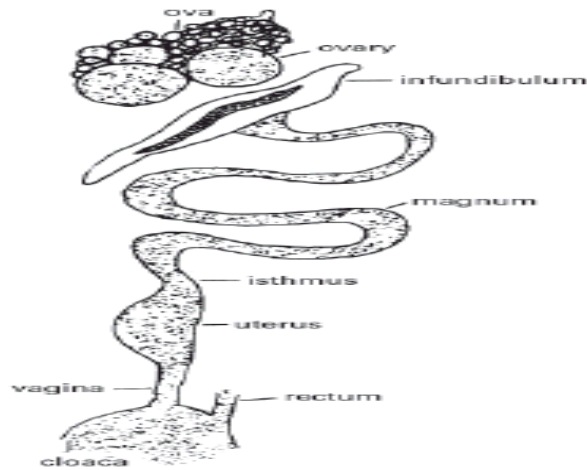


Lecture 8

EGG AS AN ANIMAL PRODUCT



FORMATION OF EGG

Figure 6: Reproductive tract of hen

The avian egg, in all its complexity, is still a mystery. A highly complex reproductive cell, it is essentially a tiny centre of life. Initial development of the embryo takes place in the blastoderm. The albumen surrounds the yolk and protects this potential life. It is an elastic, shock-absorbing semi-solid with high water content. Together, the yolk and albumen are prepared to sustain life - the life of a growing embryo - for three weeks, in the case of the chicken. This entire mass is surrounded by two membranes and an external covering called the shell. The shell provides for an exchange of gases and a mechanical means of conserving the food and water supply within

The egg is formed in the mature hen by a reproductive system composed of an ovary and oviduct. Most females have two functional ovaries, but chickens and most other birds have only one ovary and one oviduct. In this oviduct, all parts of the egg, except the yolk, are formed. It is divided into five distinct regions: (1) infundibulum or funnel, (2) magnum, (3) isthmus, (4) uterus or shell gland, and (5) vagina.

The yolk is formed in the follicular sac by the deposition of continuous layers of yolk material. Ninety-nine percent of the yolk material is formed within the 7-9 days before the laying of the egg. When the yolk matures, the follicular sac ruptures or splits along a line with few blood vessels. If any blood vessels cross the stigma, a small drop of blood may be deposited on the yolk as it is released from the follicle. This causes most blood spots in eggs. After the yolk is released from the follicle, it is kept intact by the vitelline membrane surrounding it. The release of the yolk from the ovary is called "ovulation." There is a small white spot about 2 mm in diameter on the surface of the yolk. This is the germinal disk and it is

present even if the egg is infertile. If the egg is infertile, the germinal disk contains the genetic material from the hen only. If the egg is fertile, it contains genetic material from both parents and is where embryonic development begins. The yolk material serves as a food source for embryonic development. After its release from the follicle, the yolk falls into the hen's abdominal cavity. The infundibulum of the oviduct quickly engulfs the yolk with its thin, funnel-like lips. The yolk quickly enters the magnum section of the oviduct where the dense portion of the albumen is added. The shape of the egg is largely determined in this section.

The magnum of the oviduct is divided from the isthmus by a narrow, translucent ring without glands. The isthmus is smaller in diameter than the magnum. It is here the two shell membranes form. The shell membranes loosely contain the yolk and dense white until the rest of the albumen is added in the uterus.

The egg white (albumen) is produced by the oviduct. There are four types of egg white. The outer thin white is a narrow fluid layer next to the shell membrane. The outer thick white is a gel that forms the centre of the albumen. The inner thin white is a fluid layer located next to the yolk. The inner thick white (chalaziferous layer) is a dense, matted, fibrous capsule of albumen around the vitelline membrane of the yolk. The matted fibrous capsule terminates on each end in the chalazae, which are twisted in opposite directions and serve to keep the yolk centred. The chalazae are twisted so that the germinal disk always orients itself upwards. During storage, however, the thick albumen becomes thinner allowing greater movement of the yolk.

The shell is added in the uterus or shell gland portion of the oviduct. The shell is composed mainly of calcium carbonate. It takes about 20 hours for the egg shell to form. If the hen lays brown eggs, the brown pigments are added to the shell in the last hours of shell formation.

The chalazae, two cord-like structures which keep the yolk centred in the egg, first appear in the uterus. The chalazae also function as an axis around which the yolk can rotate and keep the germinal disc in hatching eggs uppermost at all times.

In the last portion of the oviduct, the vagina, a thin, protein coating called "bloom" is applied to the shell. The cuticle somewhat seals the pores and is useful in reducing moisture losses and in preventing bacterial penetration of the egg shell. Much of the cuticle is removed from table eggs when they are mechanically washed. To replace the cuticle, table eggs are often sprayed with a light mineral oil mist. The egg passes through the oviduct small end first, but is laid large end first. In the vagina, the egg is turned horizontally just before laying. If the hen is disturbed on the nest, the egg may be prematurely laid with small end first. "Oviposition" is the act of pushing the egg from the oviduct.

When the egg is laid it is at the same temperature as the hen's body (about 105°F). As the egg cools to ambient temperature, the egg contents contract and the two shell membranes separate, generally at the large end of the egg, forming the air cell. The outer membrane sticks to the shell while the inner membrane sticks to the albumen. During storage, the egg loses water by evaporation, causing the air cell to enlarge.

Egg Formation Timeline

The average time an ovum spends in each structure as it passes down the oviduct

Infundibulum: about 15 minutes

Magnum: 2-3 hours

Isthmus: 1½ hour

Uterus: about 20 hours

Vagina: just a few minutes

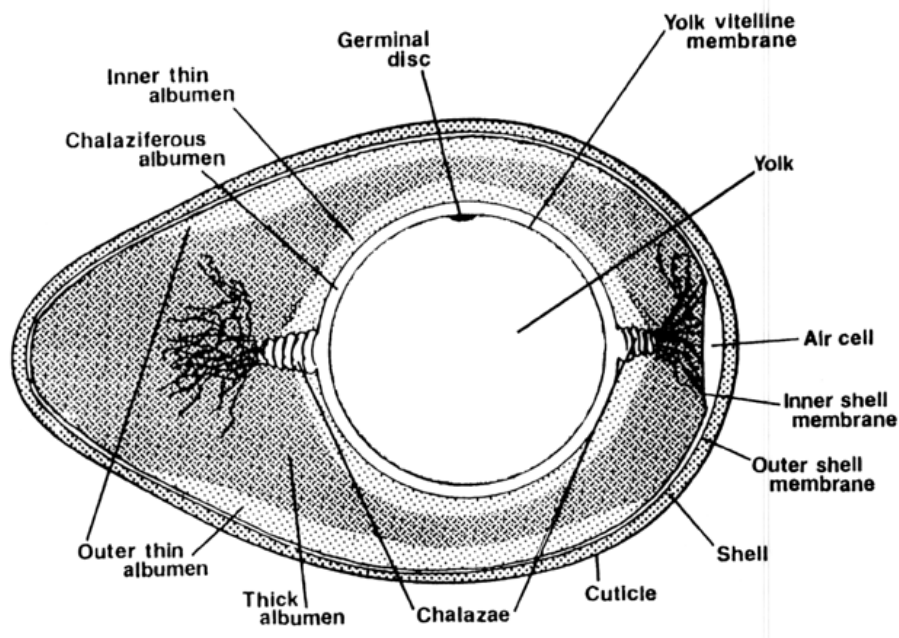


Figure 2: diagram of an egg

Egg sizes

Eggs are sorted into five different sizes according to weight: Jumbo, Extra Large, Large, Medium, Small, and Pee Wee. The following are the weight standards and approximate nutritional values associated with each of these sizes:

UK egg sizes

US egg sizes

New Size	Weight	Egg sizes	Average weight
Very Large	≥ 73g	Jumbo	71g
Large	63 - 73g	Extra-large	64g
Medium	53 - 63g	Large	57g
Small	≤53g	Medium	50g
		Small	43g
		Peewee	35g

The Nutritive Value of the Egg

The egg is one of the most complete and versatile foods available. It consists of approximately 10% shell, 58% white and 32% yolk. Neither the colour of the shell nor that of the yolk affects the egg's nutritive value. The average egg provides approximately 313 kilojoules of energy, of which 80% comes from the yolk.

The nutritive content of an average large egg (containing 50 g of edible egg) includes:

6.3 g protein

0.6 g carbohydrates

5.0 g fat (this includes 0.21 g cholesterol).

Egg protein is of high quality and is easily digestible. Almost all of the fat in the egg is found in the yolk and is easily digested.

Vitamins

Eggs contain every vitamin except vitamin C. They are particularly high in vitamins A, D, and B12, and also contain B1 and riboflavin. Provided that laying hens are supplemented according to the Optimum Vitamin Nutrition concept. Eggs are an important vehicle to complement the essential vitamin supply to the human population.

Minerals

Eggs are a good source of iron and phosphorus and also supply calcium, copper, iodine, magnesium, manganese, potassium, sodium, zinc, chloride and sulphur. All these minerals are present as organic chelates, highly bio-available, in the edible part of the egg.

Egg Grades

Grading is a form of quality control used to divide a variable commodity or product into a number of classes. The United States Department of Agriculture (USDA) standards for quality of individual shell eggs were developed on the basis of both interior and exterior quality factors. Commercially, eggs are graded simultaneously for exterior and interior quality. When determining the grade of an egg, the factor with the lowest grade will determine the overall grade of the egg. In the United States, egg grades include AA quality, A quality, B quality, and dirty. Only AA and A quality eggs are sold for supermarkets.

Egg Quality

Egg quality is a general term which refers to several standards which define both internal and external quality. External quality is focused on shell cleanliness, texture and shape, whereas internal quality refers to egg white (albumen) cleanliness and viscosity, size of the air cell, yolk shape and yolk strength.

Egg Size

The size of an egg is controlled by many factors. Among these factors including individual genetic markers, stage of sexual maturity, age, drugs and some dietary nutrients available to the bird. The most important nutritional factors known to affect egg size are protein and amino acid adequacy of a diet and linoleic acid.

Egg Shell Quality

Shell colour comes from pigments in the outer layer of the shell. Shell colour is primarily a **breed characteristic**, although there is often variation among individual hens in a particular flock even when all are of the same breed and variety. Egg shells of commercial breeds of chickens are white or brown. Breeds with white earlobe ordinarily lay white eggs while breeds with red earlobes ordinarily lay brown eggs. White eggs are most in demand among American buyers. In some parts of the country, however, particularly in New England, brown shells are preferred. The Rhode Island Red, New Hampshire and Plymouth Rock are breeds that lay brown eggs. Since brown-egg layers are slightly larger birds and require more food, brown eggs are usually more expensive than white. While darker coloured brown eggs tend to have thicker shells, shell colour has nothing to do with egg quality, flavour, nutritive value, or cooking characteristics.

The appearance of the egg, as influenced by severity of defects, is important for consumer appeal. Egg shells are evaluated on the basis of cleanliness, shape, texture, and soundness.

Cleanliness

Most eggs are clean when they are laid, but they can become contaminated with manure or other foreign material. In the United States, an egg with manure or adhering material on the shell cannot be marketed. It is classified as dirty and cannot be used for human consumption. Eggs with stained shells are unattractive in appearance and cause eggs to be downgraded to B quality or dirty depending on the severity of the stain.

Shape

The "normal" chicken egg is elliptical in shape. Eggs that are unusual in shape, such as those that are long and narrow, round, or flat-sided cannot be placed in Grades AA or A. Round eggs and unusually long eggs have poor appearance and do not fit well in cartons so are much more likely to be broken during shipment than are eggs of normal shape.

Texture

An egg shell that is smooth is preferred since rough-shelled eggs fracture more easily and have poor appearance. Eggs with extremely rough or uneven shells are downgraded to B quality. Some eggs have a rough pimply appearance. The pimples (calcium deposits) are distortions to the shell. Infection is not responsible because pimpling also occurs in disease-free flocks. The defect may be partly hereditary.

Mottled shells have pale translucent spots (sometimes called "windows") of various sizes. Such eggs appear normal when laid. The mottling develops later and may be noticeable half an hour after laying, although it is more easily detected a day later. This abnormality is inherited, although a similar effect can be induced artificially, such as when a wet, newly laid egg slides across the wire cage floor instead of rolling, or when a hen's toenail scratches the surface of a recently laid egg.

Soundness

"Body checks" are eggs with shells that have been cracked during shell calcification in the hen and have had a layer of calcium deposited over the crack(s) before the egg is laid. Some body checks are covered by a relatively thick layer of calcium before being laid so are not easily detected unless eggs are candled. Other body checks are only covered by a thin calcium layer before being laid so they are easily detected. The incidence of body checks will increase if hens are excited in the afternoon or early evening just as the egg shell begins to form in the oviduct. It is important, therefore, to keep hens as calm as possible, especially during the late afternoon and at night.

Body checks sometimes appear as ridges or bulges on the shell. Depending upon the extent and severity of the ridge or bulge, or the ease of detecting the checked area, body checks may be classified as B quality. These shells are usually weaker than normal shells, are more likely to break in shipment, and they lack consumer appeal.

Sometimes eggs have thin spots in the shell. The thin spots may appear gray and the shell is more likely to break in these areas.

Factors Affecting Shell Quality

Poor shell quality can result in downgrading. Producers should be aware of these factors so they can take preventive actions to minimize the occurrence of costly downgrades. Management plays an important role in controlling all of these factors to produce eggs of high quality. To assure the production of high quality eggs, one should select a strain of birds known to produce eggs of good quality because egg quality is a heritable characteristic. Avoid prolonged periods of temperature above 86°F in the laying house, if possible. Use high quality feeds and adjust feed formulations according to feed intake and the age of the hens. Practice the necessary steps to prevent disease and other physiological disturbances in the flock. The time pullets start to lay can be regulated by controlling feed and light in a planned program. Because egg quality decreases with the **age of the hen**, the number of years to keep a hen should be considered in relationship to all aspects of the production plan.

If one **disease** had to be singled out as being responsible for the majority of the economically significant production losses in egg layers, it would be infectious bronchitis. Not only is egg shell quality affected, but internal egg quality also declines. Watery whites are very common and can persist for long periods after egg production returns. Also, an infectious bronchitis outbreak can result in a pale-coloured shell in brown eggs. However, other factors, such as **stress**, are also responsible for causing a pale-coloured shell.

Another disease which may affect shell quality is Egg Drop Syndrome 76 (EDS 76). EDS 76 was first identified in Britain in 1976. A vaccine was quickly developed and the disease seemed to disappear. However, it has recently reappeared in the Netherlands. The disease is mainly characterized by a drop in egg production early in lay, or by a sudden fall in production at a later stage in the laying period. In the beginning the symptoms include shell-less eggs and thin-shelled eggs, deformed eggs, and, in the case of brown eggs, a loss of shell colour. In addition, the whites of these eggs are very watery, and there is considerable variation in egg weight.

Internal Egg Quality

Interior egg quality is based on air cell size, albumen quality, yolk quality, and the presence of blood or meat spots.

Albumen Quality

The albumen has a major influence on overall interior egg quality. Thinning of the albumen is a sign of quality loss. When a fresh egg is carefully broken out onto a smooth flat surface, the round yolk is in a central position surrounded by thick albumen. When a stale egg is broken out, the yolk is flattened and often displaced to one side and the surrounding thick albumen has become thinner, resulting in a large area of albumen collapsed and flattened to produce a wide arc of liquid.

Properly refrigerated eggs stored in their carton in a home refrigerator will change from AA-grade to A-grade in about 1 week and from A-grade to B-grade in about 5 weeks. However, a properly handled and refrigerated intact egg will retain its nutritional value and wholesomeness for a considerably longer time.

Egg yolk from a newly laid egg is round and firm. As the egg gets older, the yolk absorbs water from the egg white, increasing its size. This produces an enlargement and weakness of the vitelline membrane; the yolk looks flat and shows spots. As soon as the egg is laid, its internal quality starts to decrease: the longer the storage time, the more the internal quality deteriorates. However, the chemical composition of the egg (yolk and white) does not change much. Increases in albumen pH are due to CO₂ loss through the shell pores, and depend on dissolved CO₂, bicarbonate ions, carbonate ions and protein equilibrium. Bicarbonate and carbonate ion concentration is affected by the partial CO₂ pressure in the external environment.

In newly laid eggs, the yolk pH is in general close to 6.0; however, during storage it gradually increases to reach 6.4 to 6.9. Egg quality preservation through handling and distribution is dependent on constant care from all personnel involved in these activities. The quality of the egg once it is laid cannot be improved, so efforts to maintain its quality must start right at this moment. The decrease in internal egg quality once the egg is laid is due to the loss of water and CO₂. In consequence, the egg pH is altered, resulting in watery albumen due to the loss of the thick albumen protein structure. The cloudy appearance of the albumen is also due to the CO₂; when the egg ages, the CO₂ loss causes the albumen to become transparent, compared with fresh eggs.

To minimize egg quality problems two things are important: frequent egg collection, mainly in the hot months, and rapid storage in the cool room. The best results are obtained at a temperature of 10 °C. There are six main factors affecting internal egg quality: disease, egg age, temperature, humidity, handling, and storage.

Disease: Newcastle disease and infectious bronchitis produce watery albumen, and this condition may persist for long periods after the disease outbreak has been controlled.

Egg age: Eggs of several days' old show weak and watery albumen and the CO₂ loss makes the content alkaline, affecting the egg flavour.

Temperature: high temperatures cause a rapid decrease in internal quality. Storage above 15.5 °C increases humidity losses.

Humidity: high relative humidity (RH) helps to decrease egg water losses. Storage at an RH above 70% helps to reduce egg weight losses and keeps the albumen fresh for longer periods of time.

Egg handling: rough handling of the eggs not only increases the risk of breaking the eggs, but also may cause internal egg quality problems.

Storage: eggs are very prone to take on the odours of other products stored with them; separate storage is therefore advised.

The variables mentioned above are particularly important to ensure that a 1-week-old egg, properly handled, can be as fresh as a day-old egg kept at room temperature. If the egg is properly handled during shipment and distribution, it will reach the consumer's table with adequate freshness.

Storage of Eggs

1. Store eggs small end down in an egg carton to keep the air cell stable.
2. Date carton so you can use or sell the oldest eggs first and rotate your extra eggs. Try to use or sell all eggs before they are three weeks old.
3. Store eggs at 50-55°F and 70-75% relative humidity.
4. Never store eggs with materials that have an odour. Eggs will pick up the odours of apples, fish, onions, potatoes and other food or chemicals with distinct odours.
5. Never hold eggs at or above room temperature or at low humidity more than necessary. Leaving eggs in a warm, dry environment will cause interior quality to drop quickly.

How to Tell if Eggs are Still Good

Have a carton of eggs that have passed their use-by date? Here's how to test to see if they are still good.

*Fill a bowl with cold water and place your first egg inside. If the egg sinks to the bottom, it's fresh. If the egg sinks to the bottom, but stands on its point, it's still good but needs to be used soon. If the egg floats to the top, it needs to be discarded.