EGGS: PRODUCTION, QUALITY AND PRESERVATION

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Avian (birds) egg is nature's master piece. Egg is an excellent source of nutrients for humans. Egg contains proteins, lipids, inhibitors, enzymes, growth promoting factors and defense factors against bacterial invasion. Egg ranks with milk as a source of essential food elements for growth and maintenance of human health.

Egg industry is primarily based on chicken eggs. Some strains of ducks and quails also produce eggs which are useful as human food.

The topic presents the following aspects.

1. Egg production
2. Egg structure
3. Egg quality
4. Chemical composition of egg
5. Nutritive quality of egg
6. Preservation of egg
7. Egg products

1. EGG PRODUCTION

Poultry farming is the raising of ~~domesticated birds~~ primarily ~~chickens~~ for the production of meat and / or eggs. A few farms exist for rearing of ducks ~~ducks, turkeys~~ and ~~-~~domesticated goose ~~geese~~. Chickens raised for eggs are called ~~layers~~ layers, while chickens raised for meat are called ~~broilers~~broilers. A layer's egg production cycle lasts for 52 - 56 weeks. Breed, mortality rate, age, body weight, laying house, lighting schedule, culling and feed influence egg production. On an average a bird produces one egg per day. In hot and humid climate commercial hybrid laying birds produce 180 - 200 eggs. In more temperate climates birds can produce 250 - 300 eggs per year.

Aseel, Chittagong, Kadaknath and Busra are the main breeds of chicken in India. Poultry is one of the fastest growing segments of agricultural sector in India. Poultry industry has transformed from a mere backyard activity into a major commercial activity in just about four decades in India.

Backyard poultry: Birds live in free range and hatch their eggs. Their diet is supplemented with crop waste or food leftovers. The labor involved in backyard poultry production is part - time.

Farm flock: Production is slightly more specialized. Eggs are hatched at a separate location where the hatch and sexing of birds are controlled.

Commercial poultry: The farm production involves full - time labor. It is geared toward producing on a sufficient scale for the sale of both eggs and poultry meat.

Specialized egg production: It consists of separating poultry for meat and egg production. In the egg producing plant, specialized employees oversee specific aspects of egg production.

Integrated egg production: It is the most advanced enterprise and involves full mechanization and automation of egg production cycle. This includes egg laying, temperature controls, scientific feeding and mechanized egg collection methods.

Asia is the largest egg producing continent contributing to about 61.3% of the world production followed by America (19.2 %), Europe (14.9 %) and Oceania (0.4 %). China is the major egg producing (annually 21.1 million tons) Asian country followed by India with the annual production of 3.9 million tons of eggs.

2. EGG STRUCTURE

The principal parts of the egg are – shell, shell membranes, egg white or albumen, yolk, the germinal vesicle or germ spot and air cell (Fig. 1).

Eggshell: The shell is a calcarious deposit placed around the outer shell membranes in the uterus of the hen. It is about 0.35 mm thick in normal eggs. Egg shell is about 11% of the total weight of the egg. It is made of 93 – 98% calcium carbonate. The shell color is derived from

derivatives of haemoglobin. The main body of the shell consists of spongy layer, cuticle or bloom and pores.

Shell membranes: The inner and outer shell membranes consist of an unorganized network of organic fibers and mineral salts. The outer shell membrane is about three times as thick as the inner one. The two membranes give some protection to the contents of egg from outside sources of contamination.

Air cell: Air cell is formed at the large end of the egg, because of greater shell porosity at this point. Air cell develops only after the egg has been laid and commences to cool Air cell size increases with time, temperature and humidity at which egg is held.

Albumen or egg white: Albumen consists of four fractions chalaziferous layer, inner thin layer, structural or firm gel - like layer and outer thin layer. Albumen is high in water content and rich in protein. Albumen accounts for 58% of egg weight.

Yolk: Yolk consists of yolk material, latebra, germinal disc and vitelline membrane. The yolk material is high in fat content. The yolk is 31% of the total weight of the egg. The yolk may be light or dark yellow, according to the feed and the individual characteristics of the hen.

Germ spot (blastodisc or blastoderm): Germ spot lies on upper surface of yolk just beneath the vitelline membrane at the apex of latebra. In fertile eggs, embryo starts developing when egg is held at 19^{o} C and above. Egg laying period varies from 23 to 30 hours.

3. EGG QUALITY

Chemical composition, hatchability, nutritive value, physical composition, functional properties such as cooking, baking and whipping behavior and grade determine egg quality. Egg starts to deteriorate in interior quality as soon as it is laid. Storage temperature, humidity, enzymatic action and hydrogen ion concentration contribute to this quality loss.

Exterior quality

Normal egg has oval shape. Abnormal egg has rough areas with thin spots. Soundness of shell indicates whether shell is unbroken, cracked, leaking or smashed. Candling is holding an egg before the direct light in a box. Any crack on the shell is visible. Yolk shadow is prominent.

Interior quality

Air cell: When egg is laid no air cell is present. Its temperature is 40 ^{o}C and as the egg cools to room temperature, the liquids contract. Due to this contraction, the inner shell membrane separates from the outer to form air space. Evaporation of water from eggs increases the air cell size. Age, shell texture, temperature and humidity are responsible for air cell size.

Albumen: Albumen should be thick, free from discoloration, foreign body, blood and meat spots. Higher the thickness of albumen, greater is the quality. Height and width of the albumen is measured and albumen index is calculated as:

Albumen index = Height of thick albumen / Width of thick albumen

Good egg has albumen index of 0.09 - 0.1.

Haugh unit score: This is the albumen height adjusted according to the weight. Haugh unit value is determined by the following equation.

$$\text{Haugh unit} = 100 \text{ X } (H - 1.7 W^{0.37} + 7.57)$$

where H = Albumen height in mm,
W = Weight of egg in grams

Height of albumen can be measured by using Haugh meter.

A high Haugh unit value means high quality. Eggs can be graded based on air cell height and the Haugh unit score as below.

Grade	**Height of air cell, mm**	**Haugh unit**
AA	3.2	72 or above
A	6.3	55 - 72
B	7.5	31 - 55
C	9.5	31 or less

Yolk: Yolk is round and firm when fresh. As yolk ages, water from albumen enters in to yolk by stretching vitelline membrane and then yolk flattens. Development of germ, blood spots and meat spots are yolk defects. Height and width of yolk is measured, which gives yolk index.

Yolk index = Yolk height / Yolk width

A good egg has yolk index of 0.32 - 0.4.

Shell: Porosity, percent shell and shell thickness are responsible for sound shell. Shell thickness of 0.35 mm is observed in normal eggshell.

pH: The pH of albumen from fresh egg is in the range of 8.4 – 9.2. Albumen pH increases during storage due to loss of CO_2.

4. CHEMICAL COMPOSITION OF EGG

The chemical composition of a raw egg and of a boiled egg is almost the same. The protein of the egg contains all the necessary amino acids in well - balanced proportions. The proteins in thick albumen are ovomucin, ovalbumin, conalbumin, ovoglobulin and ovomucoid. The albumin contains some water soluble B vitamins, especially riboflavin. The thin albumen is much like the thick albumen with less ovomucin.

The important yolk proteins are ovovitellin and livestina. The fatty substances are mostly glycerides, lecithin and cholesterol. The yolk contains almost all of the vitamins except vitamin C. It also contains iron, sulfur, copper, phosphorus, potassium, sodium, magnesium, chloride, calcium and manganese.

5. NUTRITIVE VALUE OF EGGS

Egg albumen contains more protein and very little fat. There is an antitryptic enzyme in raw egg albumen that interferes with digestion by trypsin. Heat destroys antitryptic enzyme. The digestibility of albumen is improved by cooking.

Egg yolk contains more fat and less protein. Egg yolk is a concentrated food containing a wide variety of nutrients. The yolk is about half solid. Almost two - thirds of the solids are lipids (easily digestible) of high energy value and one third is mainly phosphoprotein. Egg yolk stimulates secretion of gastric juices. Yolk suffers a nutritional loss when it is heated longer at higher temperatures. Essential minerals like phosphorus, iron, sulfur, magnesium, potassium, sodium, chloride, zinc, copper, bromine, manganese and iodine are present in abundant.

Egg contains all essential amino acids and unsaturated fatty acids mainly oleic acid. All the vitamins are present in egg except vitamin C. As a natural source of vitamin D, eggs rank second only to fish liver oils. Liquid egg supplies various minerals, but low in calcium. Egg shell is rich in minerals (Table 1). Liquid egg protein has a biological value of 94, which is the highest of any of the major food protein sources. Enrichment of eggs with certain nutrients such as omega – fatty acids, lutein and vitamin E is done through diet of hen.

The calorific (energy) values of egg of various species of birds are not similar, because the eggs are unequal in size and are different in composition. The chicken egg has an energy value of 74 - 80 calories per 100 g. The shell yields about 1.6 calories per 100 g.

6. PRESERVATION OF EGGS

The quality attributes of albumen and yolk are lost as egg ages. Time, temperature, humidity and method of handling determine the egg quality loss. The closer the temperature to the freezing point slower is the rate of quality decline. A brief account of appropriate treatments to minimize the loss of egg quality is given below.

i. Washing with egg washing powder removes dirt / soil on the egg surface.
ii. Spraying with petroleum jelly based egg spraying oil
iii. Holding eggs in CO_2 atmosphere
iv. Sodium silicate treatment
v. Lime sealing and
vi. Over wrapping in cartons by cellophane.

Refrigeration / Freezing: At 0 ^{o}C egg keeps well for 5 – 8 months. For short period (2 – 3 weeks) egg can be stored at 10 – 12 ^{o}C. Plain egg white, yolk and variety of egg blends of yolk and white are frozen. The frozen products are marketed as ingredients for use in other food

products. Sodium chloride and sucrose are commonly added at about 10% level to frozen egg products to control gelation of products containing egg yolk. Other additives include glycerin, syrups, gums and sodium metaphosphate. Gums thicken liquid egg. Phosphates make it possible to pasteurize at a lower temperature. Triethyl citrate improves the whipping properties of egg white.

Thermal processing: The immersion of eggs in water at 49 ^{o}C for 35 minutes, at 54 ^{o}C for 15 minutes, at 59 ^{o}C for 10 minutes or at 60 ^{o}C for 5 minutes kills the embryo in fertile eggs and destroys some of the bacteria on the shell and inside. These treatments also stabilize the upstanding character of the yolk and white.

Dehydration of eggs: The dried products of egg are of two types, dried egg albumen and dried whole liquid egg. Egg albumen products are fat free, while whole liquid egg products contain the highly emulsified lipids and proteins. The dried egg products should be in uncooked state to preserve the native characteristics of raw egg. These characteristics include ability to coagulate with heat, production of stable foams when whipped, emulsifying power, color and flavor. In drying of egg, moisture is removed from liquid by evaporation. Glucose should be removed to retain the functional properties, color and flavor stability of liquid egg. If glucose is removed, the glucose – protein (Maillard) reaction producing undesirable color does not occur. In the absence glucose, off flavors arising from glucose – cephalin reaction are also eliminated. Glucose is removed from liquid egg prior to drying. Controlled bacterial fermentations using special cultures are used to desugar egg white. Yeast fermentation with *Saccaromyces cervisiae* is also employed to desugar egg white and whole liquid egg. Desugaring of liquid egg is now done by using glucose oxidase – catalase system.

Liquid egg is spray dried by heating at an inlet temperature of 121 – 232 ºC. Liquid egg is atomized by spraying through high pressure (500 – 6000 pounds per square inch) nozzles in to a hot air stream that evaporates water instantly. Air is removed by an exhaust fan. After drying, the powder is cooled, sifted and packed. Pan drying egg white is also done to produce egg albumen flakes, granules and powders. These products are commonly used for making aerated confections after reconstituting by soaking in water overnight.

7. EGG PRODUCTS

Whole liquid egg, albumen, yolk, frozen salted yolk, sugared yolk, sugared dried whole egg, dried albumen and dried yolk are used as ingredients in various food applications. There are many egg products which can be classified as (i) Pre - peeled hard cooked eggs preserved in a solution of sodium benzoate and citric acid, (ii) Improved scrambled egg mixes (Omlets) for cooking in a plastic bags and (iii) Pre - cooked – frozen – thaw – reheated egg products.

A few egg products developed recently are briefly mentioned below.

Egg chips: Egg chips are prepared by mixing the whole liquid egg with optimized quantities of refined wheat flour (Maida), corn starch, spices, common salt and pearl millet / barley / sorghum flour. The dough so prepared is flattened in to 2 – 3 mm thick sheet, cut in to 2 - 3 cm strips and fried in vegetable oil to produce ready – to – eat egg ships. The cooled fried chips packed in

metalized polyester bags, sealed with air or nitrogen gas can be stored at ambient temperature (27 ± 2 ºC) for 4 months safely. Egg chips containing barley flour absorbs less oil on frying, has higher product yield on frying and is more crispy in texture. Barley flour produces egg chips of better sensory quality compared to pearl millet and sorghum flour.

Egg loaf: Egg loaf can be prepared by homogenizing the whole liquid egg with optimized quantities of spices, potato, common salt and refined wheat flour (Maida). The mix is shaped in to loaf in a stainless steel container, steamed, cooled and cut in to slices. The slices packed in polyethylene bags can be stored in refrigerator at 4 ± 1 ºC for 7 days retaining the sensory qualities intact.

Egg albumen cubes and egg yolk cubes: Egg albumen cubes or egg yolk cubes are prepared by mixing the albumen or yolk separately with optimized quantities of wheat semolina, rice flour and common salt to obtain dough. The dough is cut in to 20 mm cubes and fried in vegetable oil. The fried albumen or yolk cubes packed in metalized polyester bags can be stored at ambient temperature (27 ± 2 ºC) for up 60 days without affecting the sensory quality.

CONCLUSION

Egg is nature's master piece. The egg is a complete set of biological substances containing proteins, lipids, inhibitors, enzymes, growth promoting factors as well as defense factors against bacterial invasion. Egg ranks with milk as a general source of essential food elements for human health. Chickens raised for eggs are layers while chickens raised for meat are broilers. A layer's egg production cycle lasts for 52 - 56 weeks. During the production cycle many factors such as breed, mortality rate, age, body weight, laying house, lighting schedule, culling and feed influence egg production. The principal parts of egg are – shell, shell membranes, egg white or albumen, yolk, the germinal vesicle or germ spot and air cell. Exterior quality parameters of egg are shape, rough areas with thin spots and cracks on the shell. Interior quality parameters are air cell, albumen index, yolk index, Haugh unit scores, shell thickness, pH and nutrient composition of liquid egg. Refrigeration, thermal processing and dehydration help preserve eggs. There are several egg products. Egg chips, egg loaf and egg cubes are recently developed egg products.

Table 1. Chemical composition of egg and egg components

Egg component (% of total)	Composition, %				
	Moisture	**Protein**	**Lipid**	**Carbohydrate**	**Ash (Minerals)**
Whole egg (100 %)	66.1	12.8 – 13.4	10.5 – 11.8	0.3 – 1.0	0.8 – 1.0
Egg shell (9 – 11 %)	1.6	6.2 – 6.4	0.03	Trace	91 - 92
Albumen (60 – 63 %)	87.6	9.7 - 10.6	0.03	0.4 – 0.9	0.5 – 0.6
Yolk (28 – 29 %)	48.7	15.7 – 16.6	31.8 – 35.5	0.2 – 1.0	1.1

Source: Eunice CY Li-Chan and Hyun-Ock-Kim 2008.

Observations:

- Egg shell is rich in minerals.
- Egg albumen contains more protein and very little fat.
- Egg yolk contains more fat and less protein.

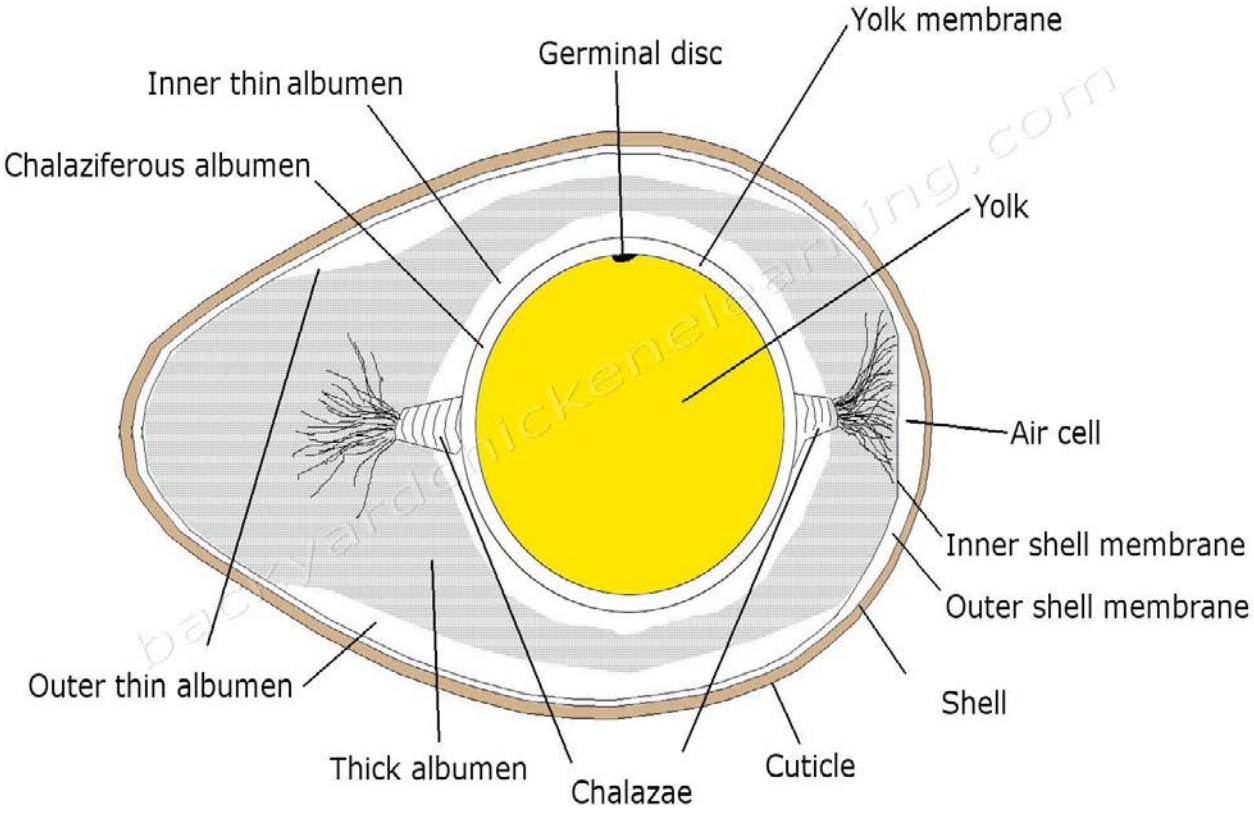

Fig. 1. Structure of egg

Source: Google search for egg structure (In May 2016)