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Review Article

INTERNAL QUALITY CHANGES IN EGGS DURING STORAGE

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Abstract: Eggs are known to be one of the complete and easily digestible foods and also second best source of protein for humans. Both external and internal egg quality deteriorates very rapidly during storage as egg is ideal medium for the development of pathogens. Soon after eggs are laid, its quality changes adversely which is mainly expressed in terms of albumin quality (Haugh Unit) and yolk quality if it is not stored at a temperature below the physiological zero. It is related to mainly loss of water and carbon dioxide which takes place rapidly when eggs are stored above physiological zero and also depends on the storage temperature and humidity. This leads to change in the pH of eggs, which results in watery albumin by changing the thick albumin protein structure. Water moves from the albumin to yolk which increases the size as well moisture content of the yolk leads to increases the pressure on the vitelline membrane that changes the shape of yolk. Numbers of other changes takes place such as loss of weight, increase in air space due to loss of moisture. Because of all these adverse change in eggs during storage results in loss of natural protective capacity of eggs, microorganisms penetrates easily and spoil the eggs at faster rate and finally reduces the keeping quality of eggs.

Keywords: Egg quality, Haugh unit, yolk index, storage time, storage temperature.

Introduction

Poultry development is one of the important activities and is one of the fastest growing sectors of animal husbandry in India. India is the third-largest egg producer in the world after China and the USA. The per capita availability reached at 69 eggs per annum in the year 2016-17 from 66 eggs per annum from previous year 2015-16. However the per capita consumption of eggs in rural areas is only half of the urban areas. One of the most challenging constraints in India to increase egg production in rural and arid India is to preserve the egg quality. Egg quality are those characteristics which affects its acceptability by the consumers such as cleanliness, freshness, egg weight, shell quality, yolk index, albumen index, Haugh unit and chemical composition (Song et al., 2000). As on today also most of our rural India does not have proper and full time electric supply, so backyard poultry farmers of those areas are forced to store the eggs under ambient environmental temperature.

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Several changes takes place in eggs during storage, and it affects the egg quality adversely if not stored under proper condition. So it is essential to store the eggs until consumption/selling under the proper storage conditions in order to preserve its quality and cooking characteristics. Chicken eggs are highly nutritious, whole and hard-boiled egg, contains approximately 12.6 g/100g protein, 10.6 g/100g fat, 1.12 g/ 100g carbohydrate and 647KJ (155Kcal) /100 g energy (Eke, et al., 2013).

Egg grading system

Based on the protein content, the United States Department of Agriculture (USDA) categorised the eggs on the basis of Haugh Units. Grade A (Jumbo egg) must have at least 72 Haugh Units, B (Extra large) must have more than 60 Haugh Units and eggs with Haugh Units less than 30 are not for consumption (USDA, 2000). In India eggs have been classified on different basis viz. size of air cell and size of eggs. On the basis of size of air cell, are Grade A having air cell size up to 4mm and Grade B having air cell size up to 8mm, whereas on the basis of size of eggs it was classified as extra large, large, medium and small.

Egg quality parameters

The fertile avian egg consists of a cuticle, a protective eggshell proper, shell membranes, albumen (egg white), and yolk bearing the blastoderm within various thin membranes. Egg shells act as hermetic seals that guard against bacterial invasion and the shell membranes function to retain the fluid of the albumen and also to resist bacterial invasion (Hassan and Aylin, 2009). The quality traits of an egg are those that directly affect its acceptability to the consumers (Rath et al., 2015). Grading of the eggs are being done on the basis of two factors i.e. external quality which is apparent from external observation and internal quality may be determined after candling or breaking the eggs. Internal egg quality start declining immediately after egg is laid and it also depends on the egg handling, storage facility, management practice and nutrition of the birds play a vital role in determining the internal egg quality. Among the various factors affecting the egg quality environmental factors such as temperature, humidity and presence of CO_2, are vital, duration of storage are also very important in terms of the maintenance of egg quality (Lacin *et al*., 2008).

In the poultry industry albumin quality or Haugh unit (HU) is considered as standard measure to judge the freshness of an egg; it is influenced by genetic factor (Johnson and Merritt, 1955) as well as by environmental factors such as temperature, time and humidity of storage (Samli et al., 2005). Haugh Unit is the precise measurement of opened egg quality, the higher the HU value, the better the albumin quality of the egg (Scott and Silversides 2000). It is the

logarithm of the height of the inner thick albumen adjusted for egg weight (Haugh, 1937). Haugh Unit are being calculated using the formula:

Haugh Unit (HU) = 100 log (H + 7.57 – 1.7W0.37

Where: H = Thick egg white (albumen) height in mm, W = Egg weight in gram

Other important measure of the standing egg quality is the Yolk Index (YI) which is the ratio of yolk height to yolk width, and can be used to assess individual egg freshness (Caner 2005). The yolk index is being calculated using the following formula:

Yolk Index (YI) = Height of yolk (mm) / Diameter of yolk (mm)

The colour of egg yolk is also used to assess the quality of eggs, being determined according to the Roche yolk colour fan (Voilleumier 1969), is one of the best methods.

Storage temperature and relative humidity

Environmental temperature and relative humidity (RH) are the main factors adversely deteriorate the egg quality during storage (Tabidi 2011), besides this extent of manipulation of egg and duration of storage is also important factor which affect the egg quality (Feddern *et al*., 2017). The longer the storage time, worse will be the internal egg quality because carbon dioxide transfer through egg shell is favoured by high temperature and humidity (Oliveira, et al 2009). The optimal storage temperature of eggs has been determined, based on the physiological zero point at which the embryonic development ceases. Interaction between storage temperature and storage period occurs either below or above the physiological zero point at which embryonic development is minimal (Brake et al., 1997). Internal egg quality deterioration of fresh shell eggs can be significantly delayed during storage by maintaining the storage temperature near the freezing point (Zeidler 2002). In normal practice eggs are often held at temperatures range of 10- 18°C (depending on local conditions) because of the expense of refrigeration and problems of condensation, particularly at temperatures below about 10°C and to reduce the egg weight loss, relative humidity should be maintained 70 to 80 % (Williams 1992). Kirk et al., 1980 reported that eggs can be stored for 8 days at 15^{o}C and 2 days at 18^{o}C safely. Eggs can be stored up to 20 days without losing internal quality characteristics for human consumption at temperature 7°C and 60% relative humidity (Alsobayel and Albadry., 2011). Eggs kept at high temperature i.e. about 37^{0}C deteriorated in quality very fast and it is not fit for human consumptions after two weeks. In hot and dry climate, where ambient temperature reaches up to 40^{o}C egg should not be stored more than one week before consumption Tabidi (2011).

Physical and chemical changes in egg quality during storage

Change in egg weights during storage

Regardless of bird's genotype, egg weight decreases during the storage period (Muhammad et al., 2014), this is mainly because of the evaporative water loss through thousands of pores contained on eggshell surface, as egg contain around 80% of water of its weight (Jozefa and Sokolowicz, 2015). Cuticle plugging the air pores of the egg shell becomes dried and begins to shrink therefore, the shell pore size increases, which leads to easier escape of gases and moisture from the eggs ultimately results in egg weight loss. Temperature of the storage environment play important role in loss of moisture from egg by evaporation. As carbon dioxide is lost through the shell pores while oxygen gets into the egg and creates an air bubble inside in-place of moisture and carbon dioxide, causing the egg to float when placed in water due to loss of weight (Hassan and Aylin, 2009). The egg quality is affected by the method and duration of storage, if egg does not stored under proper storage conditions, decrease in egg weight with increased storage time. If eggs stored under higher temperature will results in higher loss of weight than eggs stored under refrigeration (Singh et al., 2014).

Change in air cell

The freshness of eggs can also be assessed by measuring air cell size (distance between eggshell and membrane), because evaporation of water leads to a reduction in the volume of the albumen, resulting in an increase in the size of the air space (Magdalena and Drazbo 2018). Air cell size exceeds 4mm in two days at storage temperature of 21^{o}C (Samlli et al., 2005). Eggs stored under the unfavourable temperature and humidity, have significant adverse effects upon the air cells depth and reported that increase in size of air cell as a result of long term storage (Alsobayel and Albadry., 2011).

Changes in Haugh unit during storage of eggs

The albumen that surrounds the yolk, which is called the thick albumen, progressively liquefies and thins with time, transforming itself into thin albumen (Kato et al., 1994). As it is known that this leads to decline in the Haugh Unit of the eggs during storage is due to the breakdown of carbonic acid in the eggs white which produced carbon dioxide and water. The evaporation of carbon dioxide and water through egg shell pore leads to increases in the pH of the albumen to alkaline state, because of this egg white change its gel structures to lose strength and white became watery which led to loss in Haugh unit of eggs (Yimenu., et al 2017).

Albumen quality can also be measured by the pH of albumen. The pH of fresh egg at oviposition is about 7.6 (Staldelman and Cotteril, 2007) which rises during storage because of loss of carbon dioxide out from the egg through the shell pores (Muhammed and Caner 2014; and Marzec 2019). A rapid loss of CO_2 takes place particularly with the albumen, leads to a decrease in the quality until the state of gas balance is reached between the inside and outside of the egg (Tabidi 2011). At higher storage temperatures, loss of CO_2 is faster results in faster deterioration of albumin quality. The movement of carbon dioxide and moisture through the egg decreases moisture percentage of egg albumen and decreases the egg weight.

Change in Albumen viscosity

Ovomucin, proteins in egg albumen plays a major role in giving gel-like consistency to egg white and thus a role in the viscosity of the thick albumen to egg white. During storage because of loss of CO_2 leads to increase in pH causing destabilization of the protein complex leads to change in viscosity of the albumen (Li-Chan and Nakai 1989).

Change in yolk index during storage

Another change that takes place during egg storage is the flattening of the yolk. The yolk of a freshly laid egg is round and firm (Okoli and Udedibie, 2000). As we have discussed that during storage of eggs, breakdown of carbonic acid into carbon dioxide and water and then diffusion of water from the albumen to yolk through the vitelline membrane (Obanu and Mpieri 1984) to equalise the concentration (pressure) between the two phases (i.e. egg white and yolk) and this results in swelling of the yolk which in turn weaken and stretch the vitelline membrane (Watkins, 2007). This pressure eventually causes the yolk to change from a spheroid shape to a round flabby shape mass (Stadelman and Cotterill, 1995), increased water content of the yolk (Caner and Yuceer, 2015), resulted in a decrease of yolk solids concentration (Li-Chan et al., 1995).

As a result of increase permeability of the vitelline membrane leads to mix in the content of albumen and yolk causes mottling of yolks (with many pale spots and blotches which vary in colour size and shape). Storage time and temperature has also been shown to adversely affect the degree of egg yolk mottling (Coutts and Wilson, 1990). As a result of degenerations of vitelline membrane during storage, water enters the egg yolk causing the mottling, and albumen proteins also enter the yolk increasing the severity of mottling (Amiri Andi et al., 2006).

Change in microbiological properties of egg during storage

Storage conditions play vital role in preserving the microbiological quality of eggs. There is a marked increase of naturally occurring psychophilic bacteria, coliform, staphylococci, yeast and moulds on egg shell surface and in its content during egg storage (Faris et al., 2011). This is because the cuticle on the surface of the shell of the eggs stored at higher temperature dries up and starts to shrink, which leads to increase in shell pore size, making it easier for microorganisms to pass in and out of the egg shell (Eke, et al., 2013). Bacterial and fungal contamination of eggs resulting from faecal contamination and infection in oviduct results in black, red or green rot, which gives the egg looks and smells putrid when broken out of the shell. Proper handling and storage of eggs fallowing collection will minimise the chances of contamination by bacteria and fungus.

Prevention

Decreasing shed temperatures in the hotter months, combined with regular collection of eggs so reducing the time egg are exposed to high temperature, will help to reduce deterioration of the albumin before collection (Jones, 2006). Oiling of eggs with odourless, tasteless mineral oil, preferably within 24 hours of being laid, markedly improves the keeping quality of stored eggs and also help to reduce CO_2 losses and thus help maintain internal egg quality (Nadia et al., 2012; Raji et al. 2009) but it does not replace the need for cool storage (Faris et al., 2011). Application of oil on eggs to ensure retention of good quality eggs especially in the tropics and most developing nations of the world. Packing eggs under modified atmosphere extend their internal quality up to 28 days (Giampietro-Ganeco et al., 2012)

Conclusion

Egg weight, Haugh unit, and yolk index significantly decreased with increased storage time and temperature. Ph of both albumin and yolk increases with increased storage time and temperature. Therefore in the tropics and most developing country of the world it is necessary to use different management practices along with proper methods of storage in order to increase the shelf life of eggs for human consumption.

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