Biological Forum – An International Journal **15(5): 1323-1326(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

A Review on Non-Invasive Quality Evaluation of Eggs using Sensor

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(Received: 16 March 2023; Revised: 08 April 2023; Accepted: 18 April 2023; Published: 20 May 2023)
(Published by Research Trend)

ABSTRACT: The concern for food quality and safety is shared by all sectors of the food industry, government regulatory agencies, and consumers. Eggs play an important part of our daily diet. New technologies and new methods of egg processing are followed in the egg industry to improve nutrition, safety, shelf life, and taste of egg products. One of the biggest challenges for the poultry industry is providing consistent-quality egg products to the consumer. The quality detection of eggs by using sensors helps to assure the safety and quality of the eggs. The paper discusses the factors influencing the quality of eggs. A relatively short period of time may pass before eggs become unusable if they are not handled and stored properly. One of the earliest signs of deterioration is the expansion of the air cell as a result of water evaporating from the white through the pores of the shell. The ageing impact of eggs can be measured using either destructive or non-destructive methods. The aim of this work is to develop a real-time model to check the quality of eggs by using the sensors. The quality of the egg can be sensed by using the Pressure sensor, a Pic Microcontroller embedded with an analog to digital converter that analyses the weight of the egg, and the result will be displayed on both LCD and LED.

Keywords: Egg, Nutrition, Quality parameter, Non-invasive, Sensors, Shelf-life, Quality detection.

INTRODUCTION

Quality is becoming increasingly important at all stages, including packaging, Preservation, and processing. Microbiological quality is crucial and must be strictly controlled. The storage time, the possibility of contamination and their ability to influence nutrition, and the overall sensory quality of the products all play an important role in the quality control of individual raw materials (Ledvinka, 2016).

The food industry has both a legal and moral obligation to provide consumers with foods that meet all conventional quality and safety requirements. Customers who purchase raw materials, ingredients, and food contact packaging materials for the production of consumer foods must ensure that these materials are safe and suitable for use throughout the food supply chain (Alli, 2003).

Prior to processing, each egg quality parameter must be checked. Eggs can quickly reach a point where they are no longer edible if they are not handled and kept in good conditions. Evaporation of water from the white through the shell's pores and subsequent expansion of the air cell are early signs of deterioration. The yolk's flattening and the white's thinning is two additional measurable signs. Specific criteria based on morphological, chemical, physical, organoleptic (sensual), and microbiological factors determine the quality of eggs. An egg is a biological substance with numerous closely related structures. A nutritional complex made up of egg proteins, fats, sugar, vitamins, and minerals helps the chicken grow and develop. The value of eggs is primarily influenced by parameters such as the hen's weight, genetic influences, age, laying cycle stage, and other factors, which are internal and external in nature. Egg weight is measured in grams, which can vary significantly. When comparing hens laying eggs with white or brown shells, which are related to the hens' genetic origins, the influence of the genotype on the egg weight is more evident (Juliet, 2004).

In 2020, more than 86.67 million metric tonnes of eggs will be produced globally, up from 74.14 million metric tonnes in 2016. The volume of eggs produced globally has increased by more than 100% since 1990.

Since global egg production is likely to continue growing at a rate of more than 2% per year, output in 2015 could reach 71.5 million tons, with Asia contributing more than 42 million tons, or roughly 59%. It is important to note that the figures provided by the Food and Agriculture Organisation (FAO) include estimates of backyard output, hatching egg production, and commercial production (Terry and Linden 2014). Weight and regularity of shape are the two most important parameters in industries that process eggs because they determine the rate of loss during

automated processing. The proportion of the egg's longer to shorter axis determines the shape. In practise, the weight ratio of the egg yolk and albumen to the total egg weight is a significant indicator of internal egg quality. It is expressed by an egg-shape index. Haugh units, which measure the amount of albumen and egg weight, are the primary measurement of albumen quality (Ledvinka, 2016).

Quality of Egg: The egg white (albumen), albumen's relative viscosity, the shape and firmness of the yolk, its strength, and the size of the air cell are all examples of the egg's internal quality. Fresh egg yolk is round and hard. The quality of the egg yolk decreases as it absorbs water and grows in size as it ages. Thin albumin surrounding the yolk absorbs water, whereas thick albumin becomes transparent and watery as CO_2 escapes through the egg shell. The egg grades determined by both internal and external factors by the US Department of Agriculture (USDA) are depicted in Fig. 1. The majority of eggs are vulnerable to both internal and external damage by pathogenic microorganisms. Despite the fact that the majority of eggs were discovered to be sterile when they were laid, it is always possible for them to become contaminated with bacteria and fungi, which increases the chance of food-borne disease and product deterioration. The amount of nutrients available, the temperature, how the egg is stored, and how it is handled all have an impact on how quickly eggs deteriorate (Bhaskar and Sudheer 2017). Since the cuticle hardens right after the ovi-position, the pores on the egg's surface could be entry points for bacteria; these are insignificant in comparison to the potential structural flaws. A structural flaw makes it much more likely that bacteria will enter the contents of the egg. Black, red, and green rot are typically the outcomes of bacterial and fungal contamination of eggs. When it comes out of its shell, the egg looks and smells bad. Good management practises, such as regularly replacing nesting materials or maintaining cages in an appropriate manner, can prevent the contamination and deterioration of eggs caused by bacterial and fungal contaminants. After collection, eggs should be handled and stored correctly to reduce the likelihood of bacterial or fungal contamination. However, the likelihood of bacterial or fungal contamination will rise as a result of improper washing practises, high storage temperatures, and humidity. The feed source should be carefully considered because *Salmonella spp.* can be distributed via the feed (Beyer, 2005).

1. Grade AA- Indicates the good quality of egg; 2. Grade A- Slightly less quality than grade AA; 3. Grade B- Indicates that quality of egg is low.

Fig. 1. Grading system of Eggs (US Department of Agriculture Washington, DC (2000))

The external egg quality indicators are: egg weight, shell thickness, shell weight, maximum length, maximum width, and Shape index. Haugh unit, Albumen index, Yolk index, Yolk weight, Yolk diameter, Yolk height, Diameter of albumen, and Height of albumen are the internal egg quality criteria measured (Muhammad *et al.*, 2020).

Egg weight, shell quality (strength, colour, and cleanliness), and internal Quality (freshness indicators) are some of the physicochemical properties that need to be taken into consideration when grading eggs. The egg's quality and freshness are mostly affected by the temperature at which it is stored and the conditions in which it is kept. Egg grading equipment currently grades eggs at a rate of up to 180.000 eggs per hour, making it impossible for a trained human eye to control each egg individually. As a result, in order to estimate one or more quality aspects of the graded eggs, the egg grading equipment is outfitted with specially developed sensor devices. The need for rapid and non-destructive installation devices is obvious. Infected eggs must never come into contact with uninfected eggs in order to prevent infection. These new gadgets were developed in comparison to conventional quality inspection, which is often harmful and time-consuming (Bamelis *et al.*, 2003).

Fresh eggs can be easily stored for three to five weeks, depending on the conditions, in these devices. The rebound from a small impact on the egg shell is used to measure the local integrity of the egg shell. If the storage room's environment is not adequate, prolonged storage can affect the internal egg quality (Ali *et al.*, 2019).

The Haugh Units (HU) will decrease by 70 HU after one week at 25°C, reaching the acceptable level of freshness; however, after one week at 8°C, the eggs will still be very fresh (85 to 90 HU). As a result, an ideal cooling method for egg storage and transportation should be established. This is uncommon in Europe, where storage rooms are frequently maintained at 18°C throughout the year. During the hot summer months, small farms without a fully controlled storage room may struggle to maintain good egg quality.

Quality detection methods for eggs: The physical qualities of the shell, such as its strength and integrity, have been evaluated using a variety of mechanical methods. When evaluating the development of quick

and non-invasive techniques, these methods are frequently used as a reference. A device for detecting hair cracks in commercial egg grading machines is based on a mechanical technique for the non-invasive evaluation of egg shell strength and integrity (Bamelis *et al.,* 2003).

1. Near Infra-Red (NIR): While the Near Infra-Red (NIR) range has wavelengths between 700 and 2500 nm, the Visible Infrared (VIS) range has wavelengths between 300 and 750 nm. Generally speaking, light is composed of a variety of electromagnetic waves of various wavelengths. Due to chemical and physical interactions, its spectrum changes as it passes through materials. After comparing the altered spectrum to the original spectrum, features of the material's chemical and physical qualities can be connected to the optical information of the object through which the light travelled. Several investigations have conclusively related this optical data to the calibre of eggs ingested. A benefit of optical measurements is that they are rapid and non-destructive. Furthermore, it is possible to create without coming into contact with the egg, removing the chance of cross contamination. White-shelled eggs have a large internal variation in their optical transmission spectra under visible light (Bamelis *et al.,* 2003).

2. Computer Vision Techniques: Computer vision techniques are utilised in two primary applications for egg grading.

a) A computer vision system for identifying open and hairy cracks in eggs is being developed. A two-dimensional Fast Fourier Transformation was used in place of neural network analysis to extract relevant information from the images, but their detection rate was only 88%.

b) Computer vision was also used to find blood spots. 92.8% of the blood spots in eggs could be identified using a neural network detection method and colour image analysis (Bamelis *et al.,* 2003).

3. Candling method: The candling area is where defective eggs are removed from the eggs. Candling is a method that lets you see the inside and outside of eggs without breaking them. When eggs were held up to a candle while being rapidly rotated, their contents could be seen, and candling was once used to check incoming eggs for freshness by viewing their internal contents under candlelight (Vickie *et al.,* 2008).

Eggs that are dirty, cracked, or have blood stains are electronically marked during candling using a wand-like pointer. Today, trays of commercial eggs can be illuminated by powerful lights and mass scanned. Thanks to recent technological advancements, these eggs can be retrieved automatically and with minimal human involvement. Modern egg washers come equipped with automatic loading, washing, drying, oiling, candling, weighing, and packaging. Eggs are carried to the proper packing line after being candled, weighed, and separated into weight classes (Jianping, 2014).

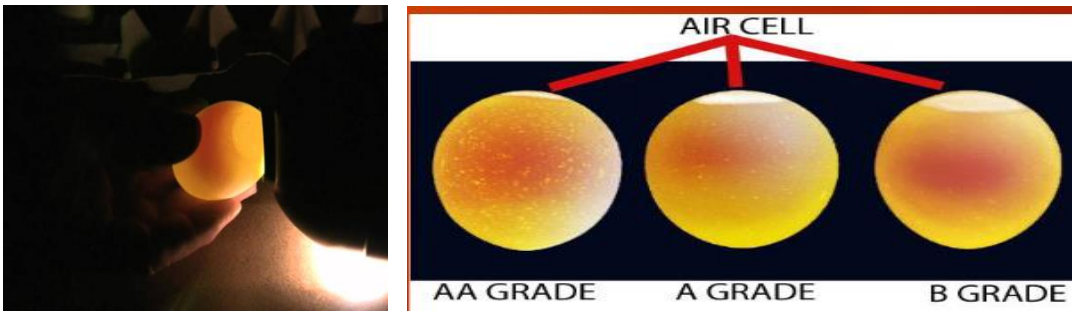

Fig. 2. Grading of Eggs by candling method.

4. Electronic Nose (EN) The state of freshness of eggs has been evaluated using a system based on the Electronic Nose (EN) that makes use of a collection of four low-cost commercial tin-oxide odour sensors. Over a period of 20 to 40 days, measurements were taken from the headspace of four egg sets. The sensor system consists of a sensor chamber that houses four identical tin-oxide odour sensors. The sensors were selected based on their sensitivity to various gases; the selected sensors are made to respond to gases like ammonia, hydrogen sulphide, alcohol, toluene, xylene, and cooking vapours, among others. When reducing or oxidising gases are present, the sensors' electrical conductance varies. As the Electronic Nose systems appear to have a lot of potential for non-invasive determining egg freshness for a number of reasons, it was discovered that the sensor conductance generally increased. The inexpensive, non-specific solid-state sensors that are sensitive to the gases released by eggs serve as the foundation for the EN systems. Additionally, an EN that has been "trained" can potentially produce results in as little as a few tens of seconds and does not require a skilled operator. A pattern recognition engine in the EN system makes it possible for the system to carry out intricate aroma analysis on the sensor signals (Dutta and Hines 2005).

The quality of the egg will be analyzed without breaking it, so this method will be termed a non-destructive method. The eggs can be spoiled in different ways due to improper storage conditions. The egg shell has void space, and through that space, air will be moved into the egg during storage, so that air will be turned into hydrogen sulphide gas, which will give a rotten smell to the egg when it is broken. The fresh egg will weigh approximately 60 to 70g; when it is spoiled, the weight will be reduced due to the presence of gas inside the egg. The quality of the eggs will be determined using the pressure sensor. The pressure sensor will be placed at the bottom of the egg trays. The pressure sensor will be connected to the PIC

microcontroller, which is embedded with Analog to Digital Converter (ADC). This is to analyse the weight of the eggs placed on the tray. The AD converter will help convert the analog values into digital values. The LCD and LED help to display the result of the egg quality, where the LCD will display the weight of the eggs and also the quality of the egg, whether it is good or bad. Green and red LED is also represent the quality of the egg. The Green light indicates that the quality of the egg is good, and the red light indicates that the egg is unfit for consumption.

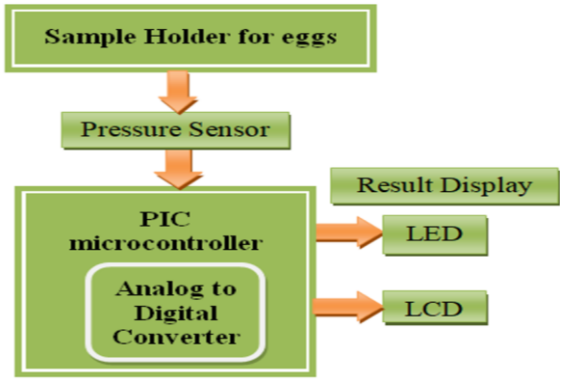

Fig. 3. Processing Flow Chart for Quality Determination of Eggs using Pressure sensor.

CONCLUSION

The producer's or vendor's intention should mainly depend on the egg reaching the consumer with as much of its original quality as possible. The quality of the egg cannot be improved after it is laid. The quality will be lowered very quickly by many factors of management and by being exposed to high temperatures and low humidity. The quality detector for eggs will be compact in size and weight, so it can be carried anywhere and in any place. Pressure sensors, which help to analyse the weight of the eggs based on the weight of the eggs, the weight of the eggs will be sensed by the sensor. In the end, the system accurately and simply informs customers about the condition of the egg. Low-cost components can be effectively used to construct the design. The design of the kit is low-cost, feasible, compact, and cost-effective. The display system clearly shows the egg freshness level, giving customers a clear understanding of its construction, which makes it accessible to all socioeconomic groups. The design is simple, effective, compact, and cost-effective.

FUTURE SCOPE

The present study is about the development of a real time model for quality checking eggs, which provides a direct and convenient means to monitor the quality of eggs and also addresses food safety. A future study on the development of quality detection of eggs with multiple sensors for large-scale industries in a continuous manner

Acknowledgement. We would also like to thank our colleagues at Avinashilingam Institute for Home Science and Higher Education for Women, School of Engineering, Coimbatore, for their feedback and support throughout the research study.
Conflict of interest. None.

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How to cite this article: Sharmeela R. and A. Lovelin Jerald (2023). A Review on Non-Invasive Quality Evaluation of Eggs using Sensor. *Biological Forum – An International Journal, 15*(5): 1323-1326.