



Egg Grader: A Review of Different Egg Grading Technologies

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ABSTRACT

The most significant challenges of marketing livestock products in non-industrial countries are improper cost estimation, absence of conservation and storerooms. Dissimilar to the industrialized countries where eggs are sorted and graded before being sold to the general population, the greater part of eggs produced in non-industrial countries are generally from smallholder facilities ordinarily in peri-metropolitan zones where there are restrictions to the availability of preservation and storage for these eggs. The shell of an egg is one of the principal lines of safeguard from outer bacterial defilement, hence, eggs with cracks on the shell surface pose greater food safety risks for customers than flawless eggs. The essential method of recognizing cracks in the shell of eggs is by the utilization of bright light in a dim room (candling) which in which the light enters the egg's shell and makes it transparent and conceivable to see the inner segments. The process of egg candling which is directed to check egg internal integrity and shell quality is performed by labourers in the dark workspace which brings worries over their occupation safety and wellbeing. Poor lighting of a working environment can prompt stress, burnout, mishaps, eye strain, cerebral pains and musculoskeletal issues. Subsequently, this paper tends to review the various technologies that are employed in egg grading including the utilization of artificial insight and machine vision.

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INTRODUCTION

In Africa, farming and agro-ventures represent over 30% of overall national gross domestic earning and a greater part of export incomes. Almost seventy-five percent of the African populace relies on agriculture as the source of their livelihoods (Heinke, et al., 2015). The Nigerian poultry industry as a case study of developing countries is assessed at ₦80 billion (\$600 million) and consists of about 165 million birds, which produced about 650,000 MT of eggs and 290,000 MT of poultry meat in 2013. From a market size viewpoint, Nigeria's egg industry is considered as the biggest in Africa having the second-biggest chicken population after South Africa's 200 million birds (Sahel, 2015). Throughout the years, however, the contributions of the livestock sub-sector to the Gross Domestic Product (GDP) in Nigeria has diminished from 5.61% in 1960 to about 2.64%

in 2010 (Aromolaran, et al., 2013). It is believed that the poultry business if properly harness can serve as a source of foreign income complementing crude oil which at present constitutes the main source of foreign earnings for Nigeria.

Poultry production as a part of domesticated animals farming is essential to the biological necessities, monetary and social advancement of the individuals in any country. The improvement of the poultry business has additionally been depicted as the quickest methods for bridging the protein inadequacy found in most developing and under-developed nations (Aromolaran, et al., 2013). Eggs are food items that give a good source of protein and are rich in iron and lime as the egg yolks particularly give fat-dissolvable nutrients (Ikbar, et al., 2019). Being the least expensive per unit source of animal protein, eggs are more

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promptly affordable by the general population than other sources of animal protein.

The low productivity of manual grading of eggs puts a genuine strain on poultry industry to develop and establish control techniques that can essentially improve the quality control of eggs, and diminish the expense of their sorting (Alikhanov, et al., 2017). With the productivity of manual sorting of eggs being under 1000 eggs for every hour, the human sorter is physically unfit to distinguish numerous defects (such as eggs irregular shape, the notch of the shell and rottenness) and cannot precisely recognize the eggs by weight, hence, the use of grading machines is widely used by egg producers (Jakhfer, et al., 2019). This write up aims at reviewing some of the existing technologies used in the grading of eggs

METHODS AND MATERIALS

Egg sorting includes the division of standard and unusual eggs into groups. The external quality of an egg can be derived from the egg size, shell tone, shell breaking strength, shell deformation (destructive or non-destructive), shell weight, percentage shell and shell thickness. The internal quality of eggs however is estimated by yolk tone, air space and egg whites (albumen) quality (Habtamu, et al., 2019). Egg sorters utilize innovation to segment eggs into standard homogeneous gatherings dependent on size, level of tainting, shell quality and use. For eggs sold for eating by human beings, the significant criteria for evaluating prices incorporate size, shell stains, cracks and freshness of the egg.

Classification based on Weight

One of the major criteria in the grading of eggs into standards is the classification of eggs by their weight. The weight of the eggs is specified according to regulation (EC) № 557/2007 by the European Commission (Jakhfer, et al., 2019). The quality groups for standard eggs are as follows:

- S – Small: from 43g to 53g;
- M – Medium: from 53g to 63g;
- L – Large: from 63g to 73g;
- XL – very large: above 73g.

Technologies Classifying Eggs Based on Weight

Asadi and Raoufat 2(010) developed a machine vision system in combination with an artificial neural network (ANN) technique for evaluating the weight of an egg using machine vision. From each sample, two pictures were captured and processed and the required highlights (for example, the width, length and shape factor) were determined for each picture and fed to a multilayer perceptron (MLP) with various training algorithms. They acquired the relationship coefficient between measured and estimated egg weight as 0.96 with a maximum absolute error of 2.3 g.

Javadikia, et al., (2011) worked on a model for the prediction of egg weight using image processing (IP) and ANFIS model. The width and length of the eggs were estimated by real-time image processing (IP) as pictures of the eggs were captured utilizing a camera. The model was planned to utilize the ANFIS model which extracted the best relation between the weight of eggs and the image processing outputs. The model got the R-value of 0.9942 and Mean Absolute Error (MAE) of 0.3285g for the real and anticipated weight of eggs.

Mahmoud et al., (2015) designed an egg volume prediction system using machine vision technique based on the Pappus theorem and artificial neural network. In the research, a basic machine vision system was produced for egg volume assessment. The numerical and artificial neural network (ANN) models were created and validated. Outcomes of model validation affirmed the excellent performance of both methods. Notwithstanding, after the calibration of the system, another investigation was performed and the outcomes showed the predominance of the mathematical modelling system over the ANN model.

Payam et al., (2015) worked on measuring the weight of egg with image processing and ANFIS model. The study attempted to quantify the width and length of the egg by real-time image processing and afterwards plan and optimise an ANFIS model to determine the best relation between the weight of the eggs and the image processing outputs. The result shows that the correlation



coefficient of experimental value for the weight of the egg and predicted value by the ANFIS model is 0.9942. This shows that the utilization of image processing and ANFIS model gives an extremely precise value for the mass of an egg.

Alikhanov et al., (2017) likewise investigated on a machine control system for automatic sorting of eggs. In this study, the premise of the working principle of the machines for eggs sorting into classes using vision system principles was determined. Sorting of eggs is accomplished by deciding the mathematical qualities of egg on the conveyor utilizing machine vision method. From the information gotten from a smart camera, an egg image processing is executed and eggs are arranged into four classes as per size in which one class is for defective eggs. Defective class of eggs consists of eggs which do not by size (excessively huge or little) and fail the conformity criterion of standard structure.

Jakhfer et al., (2019) conducted a research on the design and performance of an automatic egg sorting system based on computer vision using some basic geometric parameters of the eggs, namely: minor and major axis, area and perimeter, shape factor and shape index, to generate an algorithm which calculates the weight of the egg. The system utilized the Artificial Neural and Fuzzy Interference System (ANFIS) to train the machine to evaluates the weight of the egg. The system was also furnished with a programmable controller and frequency-controlled electric drive which takes into consideration the control of the electro-pneumatic actuators and the speed of transport conveyors. This arrangement makes the system more adaptable and permits easy readjustment while changing production requirements.

Classification Based on cracks and Shell Stains

An egg can likewise be classified depending on the level of stains and cracks on their shell and this classification is generally called exterior and interior quality classification. The characterization for eggshell with regards to stain can be slight, moderate or prominent classifications (USDA, 2000). Stained eggs are

evaluated uniquely as grade B eggs and as a guideline, a slight stain is effectively noticeable from one foot away yet hard to see from about three feet. A moderate stain can be effectively notice from three feet yet hard to see from about six feet. A prominent stain is effectively obvious from six feet or more. There are two stain types, namely, localized and scattered stains. A localized stain is a solitary stain where all the stained regions are connected. The size of the stained parts is usually added together mentally and compared with the total area of the shell for a Grade B egg (DASL, 2010).

As indicated by the classification of Pescatore, et al. (2011), grade AA or A eggs will be eggs that are perfect and may show little specks of stains, or confine marks that do not detract the overall appearance of the eggs and may likewise show traces of handling oil. On the other hand, grade B eggs are eggs that are slightly or moderately localised with stains that are under 1/sixteenth of the shell.

The eggshell break is a significant parameter that must be assessed before eggs are shipped off to the market for consumption. Broken eggs are inclined to bacterial contamination and are likewise a source of dirt. Cracked eggs are messy when stored along with uncracked eggs. The impediments of cracked eggs have created the need for improvement in eggshell crack identification innovation to guarantee food safety (Yongyu, et al., 2011).

Technologies for Classifying Eggs Based on Cracks and Shell Stains

Customarily, interior assessment of eggs, a process called candling is done independently for each egg in a dark room by the utilization of an egg candler which permits beams of light to go through the egg while the egg is turned for a complete assessment. In the case of hand candling, two eggs are taken in each hand. One egg is held with the larger end up and in a slanted position in front of the opening of the candling gadget. While held in this position, the egg is given a quick twist along its long axis which gets the yolk in motion and enable the appearance and behaviour of the yolk to be noted. After one of the eggs in one hand has



been inspected, the egg on the other hand is put before the candle, while, the position of the egg held in the first hand is turned around. Along these lines, the eggs are rotated before the candling light until all have been inspected and their quality decided (DASL, 2010).

Another technique which can be utilized in the characterization of the interior of eggs is known as the broken-out technique which is a damaging strategy for characterization. It is considered as a way for graders to build up the evaluating abilities that empower them to make correlations of broken out egg appearance with candled appearance. The most acknowledged and broadly utilized technique for deciding albumen quality is by estimating the Haugh units. HU can be determined from two boundaries; the height of the albumen (AH) and Egg weight (EW). To figure HU, the equation below can be utilized.

$$HU = 100 \log(AH - 1.7EW^{0.3})$$

Whereas, the equation below is used to compute the albumen percentage.

$$\text{Albumen \%} = \frac{\text{Albumen Weight}}{\text{Weight of the entire egg}} * 100$$

The higher the number of HU the better the quality of eggs and the qualities ranges from 0-130. The HU ranked evaluation is such that grade AA: 72HU, grade A: 71-60HU and grade B: 59-31 HU (Habtamu, Misgana, Walkite, and Lema, 2019)

Karoui et al., (2006) studied the development of a rapid method based on front-face fluorescence spectroscopy for the monitoring of egg freshness. In this investigation, the characteristic fluorescence of thick and thin egg albumens was assessed as a potential quick technique for the checking of egg freshness. The fluorescence emanation spectra of tryptophan deposits (excitation: 290 nm; discharge: 305–430 nm) of proteins and fluorescent Maillard reaction products (excitation: 360; outflow: 380–580 nm) were recorded directly on thick and thin albumen tests for 2, 3, 4, 5, 9, 10, 12, 16, 18, 23, 25 and

29 days of storage. Although fluorescence spectroscopy is a strategy whose hypothesis and technique have been broadly used for investigations of both science and organic chemistry, the utility of this spectroscopy for molecular examinations has not been at this point completely perceived in food science and particularly in the field of egg grading.

Hao et al., (2009) worked on Eggshell Crack Detection Based on Acoustic Impulse Response and Supervised Pattern Recognition. This was accomplished by the investigation of the measured frequency reaction of eggshell energized with a light component. The reaction signal was processed by recursive least squares adaptive filter which brought about an improved signal-to-noise ratio (SNR) of the acoustic impulse reaction. Given the outcomes, it was inferred that the acoustic reverberation system joined with the supervised pattern recognition has a huge potential for crack identification on eggs.

Dehrouyeh et al., (2010) worked on grading and quality inspection of defective eggs using machine vision. The algorithm depended on image processing for recognizing inner bloodspots and eggshell dirt by processing procured pictures from eggs under various enlightenments. The algorithm can also distinguish the intensity of dirt on an eggshell. The hue histogram was utilized for blood spots identification, and greatest estimations of two ends of histogram were chosen as rules for defect identification.

Loredana et al., (2011) worked on automatic identification of defects on eggshell through a multispectral vision system. The study built up an offline artificial vision system to consequently distinguish flawed eggshells (dirty or cracked eggshells), by utilizing multispectral pictures with the major purpose of adjusting the system to an online grading machine.

Mansoor, Ashtiyani, and Sarabadani (2011) examined the automatic crack detection in eggshell based on SUSAN edge detector using Fuzzy Thresholding. To check and take out the cracked eggs rapidly and precisely in the processing of egg, a non-destructive testing system dependent on Digital Image Processing



(DIP) with a proficient algorithm was created. These algorithms depend on Fuzzy thresholding and SUSAN edge indicator. The principle favourable position of this technique in comparison with other different techniques is its less sensitivity to noise because no derivative operator was utilized. As indicated by the test results, this algorithm had the best binarization on the main image in correlation with algorithm Otsu and power law. Additionally, the outcomes demonstrated that with the addition of Gaussian noise to the principle input image, the variable difference is somewhere in the range of 0.002 and 0.01. The exactness of identification for the proposed algorithm was 97% and 82%, likewise, this algorithm had least value of error function (number of error pixel) on the grey level image in comparison with other algorithms.

Meysam (2012) worked on automatic crack detection in eggshell based on Susan Edge detector using fuzzy thresholding. By utilizing an image-processing algorithm, the non-destructive techniques to recognize the cracked eggs were created. The handling time for singular image processing was about 0.3 second in the wake of changing over MATLAB codes to C++.

Vargas et al., (2018) worked on merging manual and automated egg candling to provide safety and social solution to manual egg candling. In the exploration, digital image processing (DIP) was used for egg selection and a graphical user interface (GUI) created in MATLAB was utilized to examine the images of the sample. A bi-linearization algorithm was utilized to distinguish any brokenness in the image caught. The cycle permits that lone variation from the norm on the egg-shell stay as white pixels. The white pixels were at that point counted, and through a given limit the algorithm oddballs or accepts the sample.

Bao et al., (2019) worked on cracked eggshell recognition using machine vision. In light of the examination of cracked egg images, the negative log operator was embraced to enhance cracks in the images followed by Hysteresis thresholding to acquire an ideal parallel image. The improved LFI index was then used to recognize the crack area and the non-crack region. The technique was

successfully utilized for different sorts of cracked eggshell, including those with complex surface or marginally damaged eggshells.

Tsvetelina et al., (2020) investigated the methodology for egg defects assessment using an image analysis algorithm for indirect egg defect-recognition using image processing. The mathematical information of the egg samples was gathered by image processing after which the Hue Saturation Value (HSV) and YIQ colour spaces data were utilized for egg defect identification. In addition, the study likewise built up a graphical user interface for perceiving defective eggs in the MATLAB environment through the use of computer vision. The interface is modular, which permits overhaul of the techniques and algorithms that are utilized.

Nasiri, Omid, and Taheri-Garavand (2020) proposed a novel and exact technique for egg sorting using a deep convolutional neural network (CNN), which is a state-of-the-art computer vision method to perform classification tasks. To classify unwashed egg images, VGG16 design was modified by a global average pooling layer, thick layers, a batch standardization layer, and a dropout layer. The modified model was prepared dependent on intact, bloody, and broken (breakage, crack, or opening on the eggshell) eggs, which were joined with being dirty. Execution assessment of the CNN model through 5-fold cross-validation demonstrated that it beats conventional machine vision-based models. The exactness was 96.55%, accuracy was 95.59%, sensitivity was 94.92%, specificity was 97.39% and area under the curve was 96.16%. The CNN model accomplished an average overall accuracy of 94.84 by 5-fold cross-validation.

CONCLUSION

Large population, development and growing income have prompted expanding interest in poultry products in developing and under-developed countries. The poultry business has arisen as the most marketed and quickest extending section in the animal husbandry sector. Unlike in the developed and industrialized countries where eggs are arranged and evaluated before being offered to



the general public, a dominant part of eggs produced in the developing and under-developed countries are for the most part from smallholder farmers ordinarily in peri-metropolitan regions. An improvement in the strategies for grading of the egg before sales would be in concurrence with previous studies which suggested egg grading as a showcasing procedure for Nigerian smallholder farmers as about 15% expansion in income can be acknowledged in the wake of grading and

sorting. It can likewise be said that with the characterization of eggs into homogenous sizes, it is conceivable to suitably cost the eggs and buyers' inclination for sorted eggs would expand the marketability of the eggs. Summarily, sorting and grading of eggs could guarantee fitting estimation of eggs, lessen wastage and eventually increase accruable pay to the smallholder farmers in developing and under-developed countries.

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