-

*by* Aubee Mahusay Salted Egg

**Submission date:** 27-Apr-2022 09:31AM (UTC+0800)
**Submission ID:** 1821410102
**File name:** Salted-Egg-Revised-Kagabi.pdf (567.49K)
**Word count:** 2420
**Character count:** 12343

# Salted Egg Cleaning and Grading System Using Machine Vision

***Abstract*—The electro-mechanical salted egg grading system was developed to support producers by streamlining the cleaning process, delivering a sorted outcome, saving time, decrease human resources needs, labor costs, and minimized egg breakage, consequently boosting production efficiency. OpenCV (Open Source Computer Vision Library) was employed as a development platform and the Raspberry Pi 3 Model B as a microcomputer due to its speedier and more powerful CPU, which is required to operate the system's components and process the acquired images for classification. In addition, a Raspberry Pi camera module V2 was employed to capture the images for scanning, LED bulb for candling, and an SG90 micro servo for sorting. Furthermore, we used B66 and B35 v-belts for the conveyor assembly. An induction motor of 0.125 horse power is used to rotate the conveyor assembly and a chain and sprocket to reduce its speed. The researchers also used soft bristles brushes which are ideal for cleaning the eggshell. For cleansing, sprinklers were used along with the water PVC pipe that holds pressurized water of 30 psi. The camera's captured images are categorized as clean, dirty, well-pickled, and spoilt eggs. Empirical results exhibited that the detection accuracy achieved 96% and 92% for cleanliness and quality, respectively. It establishes the model and prototype's robustness in cleaning, sorting, and grading salted eggs.**

***Keywords*—*automation, candling, computer vision, egg quality tests, image processing, microcomputer***

## I. Introduction

Salted duck eggs, also known as 'itlog na maalat' in the Philippines, are a staple food, particularly during breakfast. It can be eaten alone, with steamed rice, or in salad style with dried tomatoes and onions. Moreover, it is also utilized as ingredients for pastries and toppings on bread and other pastry kitchen products [1]. In addition to serving as a regular dish in whole eggs, the salted yolks are also used as stuffing material in some foods such as moon cake, other desserts, and glutinous rice dumplings [2]. Salted eggs are food products that are preserved by soaking duck eggs in brine for an extended period of time. Salting prolongs the shelf life, adds value to the development, and offers ease of serving retailers and consumers. The conventional method of making salted eggs is to mix clay, table salt, and water in precise proportions until the batter is smooth and viscous. It is dipped in the mixture enough to coat the egg and is stored at room temperature for 15 to 16 days - the salt equilibrating in the batch by osmosis [3] [4]. After the curing period, the eggs are hand-cleaned with water, brushed, and prepared to be boiled [5]. Since the eggs are soaked in mudded brine, they require washing before carrying out the boiling operation. Most salted egg producers manually cleaned the dripping eggs using human hands; the eggs were washed one by one, which sometimes caused shell breakage and inconsistency. Hence, it consumes a lot of time and coerced labor, causing inefficiencies.

Scanning salted eggs as either cracked or rotten have not been fully applied in the industry, which results in unconformity to the hygienic standards. The manual egg candling process is labor-consuming and prone to human errors and is not very efficient due to the exhaustion of workers who have to check thousands of eggs per day [6 - 11]. Therefore, developing an accurate, rapid, and low-cost machine vision system for detecting rotten or cracked eggs at a reasonable time would be advantageous to the industry [12]. In this context, the salted egg producers face a two-fold and conflicting problem, and their system production to perform successfully. With this dilemma, the proponents created a salted egg washer, scanner, and sorter that could improve the hygienic condition and save up time, workforce, and financial costs.

## II. Materials and Methods

### A. Materials

Salted eggs came from Brgy. Sampaga, San Antonio, Quezon. Salted egg can be graded as clean and dirty in the process of cleaning and they will be categorized as well-pickled and rotten eggs for the scanning process. The microcomputer used in the system was Raspberry Pi 3 module B. It was used in the scanning operation of the salted egg. It is a powerful processor with wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs. The Raspberry Pi is a credit card-sized computer. It based on the BCM2837 system-on-chip (SoC), which includes a 1.2 GHz quad-core ARMv8 64bit processor and a powerful video core IV GPU [17].

Fig. 1. Raspberry Pi 3 Module B

The camera used in the system is Raspberry Pi camera (module V2) which operates at 8 megapixels that features a high quality 8-megapixel IMX219 sensor array mounted on a precision add-on chip for the microcomputer. It connects to the electronic device via one of the connectors on the board's surface with CSi interface, built specifically for camera communications [18].

Fig. 2. Raspbery Pi Camera

The system utilized three micro-servo motors that pushed the salted eggs from the scanner and sort out to which container they should be. The identified motor is lightweight and compact, yet it generates a significant amount of power. It turns roughly at 180 degrees and functions comparable to a regular servo but considerably smaller. Additionally, it incorporates a potentiometer, and a controller circuit. The control wheel is connected to the motor through a set of gears. Due to the fact that the resistance of the potentiometer changes as the motor rotates, the control circuit is able to accurately regulate the amount of movement in various directions [19].

Fig. 3. SG90 micro-servo motor

*B. Egg Washing System*

The egg washer consists of conveyor assembly with two flexible V-belts that are perpendicular to each other and are entrained to various pulleys as the driving member. Plastic blades are attached to the belts to hold the eggs during the transport. There are nylon brushes that wash off the dirt on the surface of the eggshell. The eggs would be cleaned as they tumbled through the brushes. Induced friction between the egg and the brush would clean the eggs. The B66 V-belt is designed as a U-shaped conveyor while the B35 will serve as a linear conveyor attached to the scanner. The rotation of the conveyor assembly is imparted by an AC 1/8 HP induction motor whose speed was reduced through double speed reduction. On static position are brushes that serve as one of the factors in cleansing the salted egg. Displaceable cover of the entire conveyor assembly consists of support framework that supports the pipe in holding the pressurized water in cleansing the salted egg. Maximum pressure of water is 30 psi. Beneath the pipe are another set of brushes that serve as additional means to cause rolling of salted egg during transport in the cleaning area and to subject the salted eggs to scrubbing actions of the brushes to facilitate and increase the efficiency of cleaning process.

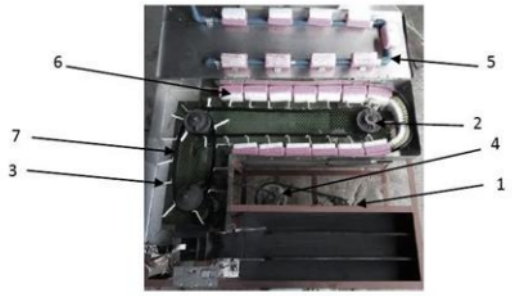



Fig. 4. Washer assembly: (1) induction motor, (2) pulley, (3) plastic blades, (4) chain and sprocket, (5) water pipe, (6) brush and (7) belt

*C. Egg Scanning and Sorting System*

The scanning system of salted egg is composed of mechanical transmission and a machine vision system. The machine vision system is composed of LED lamp, camera, image acquisition card (SD card) and a microprocessor [12 – 15]. The mechanical transmission of the scanning system has three servo motors directly connected to the pin assignment in microprocessor. As shown in Fig. 5, servo motor 1 and servo motor 2 are set on the left and right side of the scanner respectively and servo motor 3 is placed on the back side of the salted egg. The camera is set directly above the salted egg and incandescent bulb is placed beneath the salted egg. The camera acquires the images and at the same time serves as a sensor- image sensor in the scanning system. When the salted eggs reach the scanning process through conveyor and completely block the light source coming from the LED lamp, a signal was sent to the microcomputer by an image sensor [12 - 15]. Then, a microcomputer sent an instruction to the camera

to capture color image of the salted eggs. The captured image was shown in Figure 5. In accelerating image processing, we converted the scans into binary images shown in Figure 6. The optimal threshold of the images [16] was determined to sort out the salted egg using a sorting arm connected to the servo motor. The percentage of white presence determined the characteristics of the scanned egg.

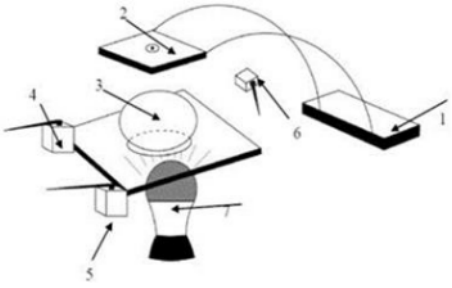



Fig. 5. Scanning and sorting system:
(1) Microcomputer, (2) Pi camera, (3) salted egg,
(4 – 6) servo motors, and (7) led lamp

The clean sensitivity ranges from 0 % - 25 % of white presence, rotten is under 70% - 90% and the dirt sensitivity of the salted egg ranges from 90% - 100% of white presence. Finally, after analyzing the obtained binary image and optimal threshold, the microprocessor sent an instruction to servo motor 3 to make an angle of 45° to push the egg to the container. Servo motor 1 and 2 are also instructed to make an angle of 0°, 45° and 315° depending upon on the analyzed data.

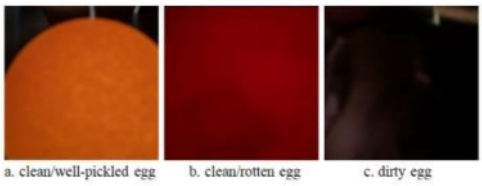



Fig. 6. Color image of scanned salted egg:
(1) Clean/well-pickled, (2) clean/rotten, and (3) dirty egg

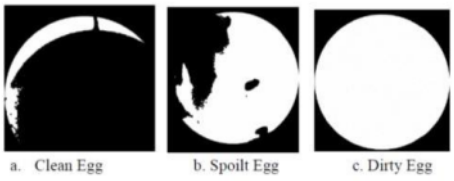



Fig. 7. Binary image of scanned salted egg:
(1) Clean, (2) spoilt, and (3) dirty

Figure 8 shows the diagram of the scanning and sorting process of the prototype. The process starts when the sensor detects salted egg within the range of the sensor. Through the camera, an image will be captured then the signal will be sent to the microcomputer to decide if the image captured is clean. If the image conforms to "NO", microcomputer will send an instruction to two servomotors to make an angle of 315°. On the other hand, if "YES", the process continues and will ask if "Spoilt salted egg?" if "YES", microcomputer will send instruction to the two servomotors to make an angle of 45°, else, the servomotors are on 0° position.

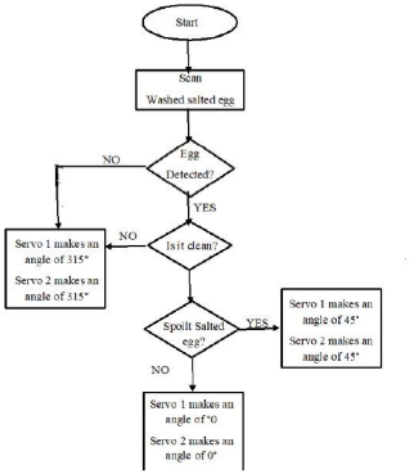
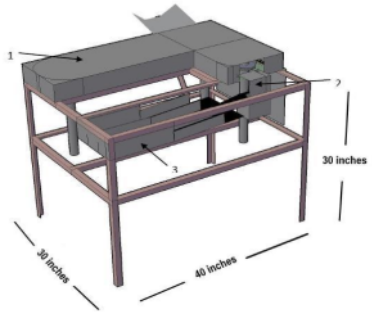



Fig. 8. Process flow diagram

### *D. Developed Prototype Evaluation*

The machine measures 30 inches (height), 30 inches (width), and 40 inches (length) enough to carry the 3 major parts of the grading system; the washer, scanner with sorter and the container.




*1. Salted-egg Washer 2. Salted-egg Scanner 3. Container*

Fig. 9. Design of the salted egg grading machine:
(1) Washer, (2) scanner, and (3) container

Fig. 10. Actual salted egg cleaning and grading prototype

### *E. Accuracy Tests of the Salted Egg Grading System*

One hundred (100) salted duck eggs were used to evaluate the prototype's performance. Each test sample was purposely muddied and put into the feeder. Then, a feeder moved down the test subject individually to a conveyor for transportation to the washer driven by the gear motor assembly. A microcomputer was used to control the motor. Spacers were used to separate the samples. Then, all eggs were cleaned with a brush and pressurized water before being scanned by the camera to determine their classification. They were typed according to the cleanliness of the eggshell and labeled as clean or unclean following washing. Clean salted eggs were separated and placed in a container. To determine their quality, the identified clean salted eggs were compared to manually mark well-pickled and rotten/spoiled eggs.

## III. Results and Discussions

We generated samples of salted duck eggs (a mixture of clean and unclean well-pickled and spoilt/rotten eggs) and muds and introduced them to the machine's feeder for cleaning/washing, scanning, and sorting. For testing purposes, dirty eggs will be separated and not included in the determination of egg quality. Manual effort was used to assess and mark the clean salted duck eggs. The tagged salted eggs were then mixed and randomly placed in the container before being transported to the conveyor to begin the scanning and sorting procedure. The results of the cleaning of salted eggs are shown in Table 1. 100 mudded eggs were utilized as a control sample for the detection of cleanness. They were placed in the container and fed onto the conveyor, where they were scanned by the camera to determine if they were clean or unclean. After cleaning the salted eggs, they were scanned and categorized according to their quality, which was determined by whether the egg was well-pickled or spoiled. There were 85 well-pickled and five damaged eggs among samples. Following the conclusion of the testing, the number of accurate and incorrect judgments was recorded.

TABLE 1
RESULTS OF SCANNING AND SORTING FOR CLEANLINESS OF SALTED EGGS

| | **Image processing detection** | | | |
|---|---|---|---|---|
| **Egg grade** | **Clean** | **Dirty** | **Total** | **% Correct Identification** |
| Clean | 86 | 4 | 90 | 95% |
| Dirty | 0 | 10 | 10 | 100% |
| Total observed | 86 | 14 | (96/100) [a] | |
| (%) | 100% | 71% | | 96% |

a. No. of salted eggs correctly classified by the machine

The result shows the number of scanned and sorted salted eggs using the prototype's mechanism. The system has detected 95% correctly classified clean salted eggs and 100% dirty eggs. It has a mean accuracy of 96%.Table 11 shows the number of scanned salted eggs according to their quality. The system has detected 95% accuracy on the well-picked and 60% on the rotten samples. The scanner and sorter have an acceptable 93% recognition rate.

TABLE 2
RESULTS OF QUALITY GRADING SYSTEM OF SALTED EGGS

| | **Image processing detection** | | | |
|---|---|---|---|---|
| **Egg grade** | **Clean** | **Dirty** | **Total** | **% Correct Identification** |
| Well-Pickled | 81 | 4 | 85 | 95% |
| Dirty | 2 | 3 | 5 | 60% |
| Total observed | 83 | 7 | (84/90) [a] | |
| (%) | 98% | 43% | | 93% |

a. No. of salted eggs correctly classified by the machine

## IV. Conclusions

An intuitive system for cleaning and grading salted eggs was developed and applied in accordance with the cleanliness and the quality of salted eggs. Mechatronics systems were designed and developed, with the Raspberry Pi 3 microcontroller and a Raspberry Pi camera serving as a machine vision component. The results demonstrate that the system effectively completed the cleaning procedure and accurately categorized the salted eggs as clean or dirty before grading them as well-pickled eggs or rotten eggs based on their quality level. The system establishes its accuracies according to extensive testing.

## V. Future Research Direction

Our design, algorithms are not perfect and considerable improvements are recommended. Alternative deep learning algorithms will be considered for increasing the accuracy of classifications. In terms of modifications, multiple scanners will be incorporated in the next version of the prototype instead of a single scanner to augment productivity or production concerns.

## Acknowledgements

We want to thank the Southern Luzon State University, especially the student authors, for the consent to publish their work and to all faculty contributors.

-

ORIGINALITY REPORT

| 7% | 3% | 4% | 3% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Mahdi Hashemzadeh, Nacer Farajzadeh. "A Machine Vision System for Detecting Fertile Eggs in the Incubation Industry", International Journal of Computational Intelligence Systems, 2016<br>Publication | 1% |
| 2 | Submitted to Nanyang Technological University<br>Student Paper | 1% |
| 3 | Submitted to Manuel S. Enverga University<br>Student Paper | 1% |
| 4 | en.wikipedia.org<br>Internet Source | 1% |
| 5 | maxwellsci.com<br>Internet Source | 1% |
| 6 | www.ijtsrd.com<br>Internet Source | 1% |
| 7 | Zhiwen Long, Chengxiao Yu, Xiaokang Zhang, Li Zhu, Hongwei Wang, Siyu Lin. "Measurement and Analysis of Radio | <1% |

Coverage in Tunnel Boring Machine", 2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI), 2021

Publication

| | | | |
|---|---|---|---|
| Exclude quotes | Off | Exclude matches | Off |
| Exclude bibliography | On | | |

-

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4