Image Analysis for Smart Machine of Nutmeg Sorting

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Abstract. Nutmeg is an Indonesian agricultural commodity that has been recognized and interested by the world import market. In the last decade, several cases of export of nutmeg from Indonesia have been rejected due to post-harvest handling contaminated with Aflatoxin. One of the causes is the process of sorting and guaranteeing the quality of products that are done traditionally and not yet perfect. This paper presented the prototype development of image acquisition station using two cameras to capture nutmeg surface in smart sorting machine. In addition, the ultraviolet light was added to ease the detection of aflatoxin using colour segmentation method. Moreover, based on SNI 01-0006-1993 and SNI 01-0007-1993, there are some criteria to categorize the quality of nutmeg such as shape, texture and colour. The experimental study of image analysis showed that our proposed sorting system could classify nutmeg based on SNI and calculate contamination area of aflatoxin.

1. Introduction
The commodities of nutmeg and mace are special Indonesian agricultural products that not only have great potential but also challenges. Both of products are in demand by global and national markets because they are used sustainably as spices, food, beverages, medicines, perfumes and cosmetics [1] [2]. One of the important keys in this trading is product quality. In fact, this agricultural product has a non-uniform quality because it is related to the post-harvest process. Some products could be contaminated by Aflatoxin or eaten by insects. The poor post-harvest handling will reduce the product quality level. Moreover, the lack of quality control of the product increasingly expands the failure of trade in this nutmeg commodity. The United Nations Development Programme (UNDP) which has program in Fak-fak, Papua, Indonesia, reported that farmers commonly handle the post-harvest traditionally with makeshift equipment and done less hygienic [3][4].

In previous researches, the authors proposed some agriculture machine such as conveyor machine [5], drying machine[4], and sorting machine[6][7]. Those machines help farmer to work with effectiveness, less time consuming and standardized. In fourth industrial revolution(4IR), industrial processes will experience great changes[8]. Therefore, Micro, Small, Medium Enterprises in Indonesia need to implement the proper technology to increase the quality of product. To deal with the quality control in sorting and grading machine for nutmeg product, we proposed the prototype of the image acquisition tool that able to capture the whole surface of nutmeg. After that, the shape, texture and color could be identified to categorize the nutmeg quality.
However, there is one other problem that can impact the nutmeg quality that is aflatoxin issue. For this issue, Bola explained a comprehensive information about the handling, analyzing, detection and health risking regarding to aflatoxin[9]. In addition, automatic machine system has also proposed to detect Pistachios which contaminated by Aflatoxin[7]. Then, the using of ultraviolet light is implemented in our image acquisition tool to help recognize the aflatoxin object. Furthermore, image analysis is used to extract the feature information related to the quality standard that noted in SNI 01-0006-1993 and SNI 01-0007-1993.

Systematically, the paper is divided into five sections: The next section of this paper describes a review of some related literatures such as the characteristics of nutmeg, aflatoxin and image analysis. Following this, the design of image acquisition and image analysis method are explained in the third section. Some implementations and evaluations of the proposed smart system are shown in the fourth section. The ending section sums up the work is and describes some potential developments for future research.

2. The Characteristic of Nutmeg and Aflatoxin

2.1. The Characteristic of Nutmeg

Indonesia is the largest Nutmeg producer country (75%). Then, Grenada as known as the best quality nutmeg producer, only provide 20% and the rest comes from Papua New Guinea, India, the Caribbean and Sri Lanka. The fruit of nutmeg consists of mace, shell of nutmeg, and Nutmeg fruit flesh (as shown in Figure 1). Every component has some benefits, such as mace for cosmetics and perfume; nutmeg for spice; fruit flesh for foods.

For product quality purposed, nutmeg means that it has been dried and peeled from shell skin, round or oval between 20-40 mm in length. Based on SNI 01-0006-1993, there are four type of quality: Calibrated Nutmeg (CN), ABCD Average, Rimpel (Shrivel) dan BWP (broken, warmy, punky).

![Figure 1. The components of nutmeg fruit](image)

| Calibrated Nutmeg | ABCD Average | Shrivel | BWP |
|-------------------|--------------|--------|-----|
| Weight (gram)     | 4.11-8.33    | Relative weight | Relative weight | Relative light wrinkles |
| Shape             | All around and no wrinkles | All around and less wrinkles | Not all around and wrinkles | wrinkles |
| Broken Contaminated (%) | No | No | No | Yes |
| Contaminated (%)  | < 10         | < 10    | < 10  | NA   |

Table 1. The quality of nutmeg classification based on SNI 01-0006-1993.
2.2. The Characteristic of Aflatoxin

Aflatoxin is a group of toxic compounds (mycotoxins, toxins derived from fungi) which are known to be deadly and carcinogenic to humans and animals. This poison was first accidentally discovered in the 1960s, which caused one hundred thousand turkeys to die due to Turkey X disease. Similar events occurred in Uganda and Kenya. Fungi (mycologists) found that peanuts from Brazil were not suitable and toxic to ducks. Researchers from the UK then found the cause of death of livestock because of the poisonous peanuts, which were used as animal feed [7].

The toxin is produced by a group of fungi (genus) from the genus Aspergillus, especially A. flavus (from here the name "afla" is taken) which is associated with oily or high carbohydrate grain products. Aflatoxin content is found in legume seeds (peanuts, soybeans, pistachios, or sunflowers), spices (such as cilantro, ginger, pepper, turmeric, and nutmeg), and cereals (such as wheat, rice, sorghum, and corn). This mold usually grows on storage that does not pay attention to the humidity factor (min. 7%) and high temperature. The tropics are the most ideal breeding grounds. Heating up to 250 Celsius degree does not effectively activate these compounds. As a result, contaminated food is usually not consumed anymore [7].

The aflatoxins will show fluorescence under ultraviolet light [10]. In nutmeg case, the aflatoxins color is identified as purplish. Meanwhile, the area of nutmeg that not contaminated by aflatoxins is darker than the area of aflatoxins (shown in Figure 2). If the true color image of nutmeg is transformed to HSV color, then the hue channel provide significant difference between aflatoxin and non-aflatoxin area. Therefore, it could be easier for segmentation task to separate the area of aflatoxin which has lighter color than other.

![Figure 2](image-url) Figure 2. The true color nutmeg under ultraviolet light and the hue, saturation, value channel of nutmeg image (left to right)

3. Methodology

3.1. The Design of Image Acquisition Process

![Figure 3](image-url) Figure 3. The design of image acquisition process of nutmeg
Figure 3 shows the design of capturing process of nutmeg image. The most prominent feature is that the nutmeg captured from two sides using top and bottom camera. It can be seen that image acquisition process starts from the movement of conveyor belt carrying the nutmeg. The flow of nutmeg came from left to right heading to shield. When nutmeg lie in transparent glass, UV lights that located in the corner of shied will emit the light, and both cameras will take image with distance about 9.5 cm from transparent glass. The obtained image used as input to image analyser. After acquisition step, transparent glass will move sideways and shake down the nutmeg to bottom conveyor belt. On the other side, image analyser will determine whether the nutmeg has a high level of aflatoxin contamination or not. Then, results will be showed in screen.

3.2. The Design of Image Analysis
The goal of image analysis is to calculate the quantitative value of image so that the image description is extracted. Feature extraction is the key point to identify the object. There are some operations that help to analysis the image such as region representation, edge detection and boundary extraction morphology.

The input image in this system is obtained from 2 cameras. The image format is true colour of 24 bits. The design of this image analysis is divided into three parts. The focus of first step is to calculate three variables such as height, width, and area of the nutmeg. The area of nutmeg is measured based on 2D captured image. In the first step, the input image is converted into grayscale image. Then, the edge detection is implemented by using canny approach. After that, the height variable (semi minor axis) and the width variable (semi major axis) area are measured from properties of image regions.

The second part is focused on calculating the area of aflatoxin. In this case, the input image is changed into HSV format. To segment aflatoxin object, the Otsu method is applied based on the hue channel. The area of aflatoxin is summed up from all connected component of white object. The last, the main goal of third part is to sort the nutmeg based on some variables that consist of three conditions.

![Figure 4](image.png)

Figure 4. The flowchart of nutmeg image analysis for aflatoxin contamination.
4. Experiments and Results

Two phase experiments have been conducted in this study. The first experiment is to test image analyser for classifying shape and texture of nutmeg image. Based on 22 images that obtained from initialized acquisition process, the proposed system gave promising results by returned the suitable class and characteristics detected of nutmeg images (see Table 2). Figure 5 shows samples of RGB and binary of nutmeg images.

![Figure 5](image)

Figure 5. The four nutmeg images: (a) Sample 1; (b) Sample 2; (c) Sample 3; (d) Sample 4;

| Sample Image for one side | Major Axis Length (px) | Minor Axis Length (px) | Orientation | Centroid (x,y) | Nutmeg Area (px) | Wrinkle |
|---------------------------|------------------------|------------------------|-------------|----------------|------------------|---------|
| Sample 1 (148x104 px)     | 94                     | 70                     | 3           | x=72, y=48     | 5167             | Rare    |
| Sample 2 (148x104 px)     | 100                    | 72                     | 3           | x=75, y=56     | 5653             | Rare    |
| Sample 3 (148x104 px)     | 90                     | 69                     | 87          | x=79, y=54     | 4905             | Many    |
| Sample 4 (148x104 px)     | 96                     | 84                     | -85         | x=76, y=53     | 6301             | Many    |

The second phase experiment that conducted in this study is to test ability of image analyser to detect and calculate contamination area of aflatoxin. From the RGB image as input, the proposed system detected boundary and nutmeg area first, then try to calculate area of aflatoxin based on HUE channel differences (see Table 3). Figure 6 shows image analyses proses from RGB image until binary image to find area of aflatoxin.
Figure 6. Some resulted image from image analysis process of top side of sample 5 (a) and bottom side (b) (left to right): raw image, boundary image, nutmeg area image, aflatoxin area image

Table 3. The results of aflatoxin contaminated analysis on a sample of nutmeg image

| Sample of One Side Image | Major Axis Length (px) | Minor Axis Length (px) | Orientation | Centroid (x,y) | Nutmeg Area (px) | Aflatoxin Area (px) |
|--------------------------|------------------------|------------------------|-------------|---------------|------------------|---------------------|
| Sample 1 upper side (148x104 px) | 107 | 89 | 40 | x=75, y=56 | 7,425 | 1,309 |
| Sample 2 bottom side (152x116 px) | 143 | 105 | -18 | x=78, y=58 | 11,720 | 1,241 |

Total 19,145 2,550 % contaminated 13.32

5. Conclusion
The contamination of aflatoxin in nutmeg become a big issue especially for Indonesia as one of the major exporters in this business. To overcome with the problem, smart machine of nutmeg sorting had been tried to develop. Image processing technique were investigated in order to classify nutmeg based on SNI and calculate contamination area of aflatoxin. The proposed system gave promising results based on the given data. However, this research should be up scale to know the robustness of proposed system in minimum for home industry.

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