Image Processing Analysis of Prevention for Mold Growth on Bread using Negative Ion Technology

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***Abstract*—Recently, molds on bread can cause Diarrhoea, allergic reactions and respiratory problems. The molds like Aspergillus, Fusarium and Penicillium can produce "Mycotoxins" which is a poisonous substance that can damage the health qualities. Thus, the prevention of mold growth on bread by using negative ion technology is the best alternatives to break the disease. The effect of negative ions can be classified as the spatial distribution of charge particles, sheath structure and collaboration of ozone and negative air ions to prevent microorganism. In this paper, image processing has been used to analyse the image obtained from the bread after a week. Two experiments have been compared to keep track the effect of negative ions on prevention of mold growth on bread which are bread placed in boxes with direct current (DC) fan or without it. In set one, the mold percentages of bread that exposed to negative ions is 3.47% while the bread that does not expose to negative ions is 14.60%. Moreover, for the set two, the mold percentages of bread that exposed to negative ions is 1.18% while the bread that does not expose to negative ions is 14.18%. Set two have a lower percentage of mold as compare to set one due to the air ventilation of the experiment set up. Each of experiment has been analysed using color filtering processing and the result shows that negative ions were successfully in the prevention of mold growth on bread.**

***Index Terms*—Bread; Mold; Negative Ion; Colour Image Processing.**

I. INTRODUCTION

An oxygen atom charged with an extra electron is called negative ions. It helps to clear the air in a room or houses of allergens like pollen, mold and hazardous airborne particles such as bacteria and viruses and have some astonishingly effects on our health. Thus, the air quality of indoor air can be improved by negative ions [1]. Negative ions raise the sense of well-being and mental intelligibility by eliminating the devastating effects of excessive positive ions in surrounding environment which it also helps to lift mental concentration and performance [2].

Many industrial instruments for the colour analysis of the food matrix dimension are defined for quality efficiency, but they basically need variables, real coordinate position and soluble samples to achieve average values, providing the desired measurements but making the samples unusable. Sensory analysis such as negative ion generator is a good tool to establish the shelf life of bakery products, providing an efficient model of the characteristics accepted by consumers and besides that, another rapid instrumental experiment that provides qualitative information regarding the emergence of a food product, such as image analysis is one of the best additional steps to be implemented.

Image analysis is a relevant technology that helps to access measurements from digitalised images. These measurements produce purpose evaluations of the colour format features of samples, a method that is more quantitative and less subjective than the common method of visual perception, which is exposed to alteration due to the personal views of quality inspectors [3][4].

Nowadays, many software programmes for image analysis and processing are widely available on the market helps researchers to analyse the digital images in real time with accurate and precise measurements of the texture, shape, colour and size of the sampled objects. Many studies have exposed the tools of image analysis for the research in colorimetric and morphometric characteristics in bakery products, fish, meat, fruits and consumer products [5-8].
Bakery products are the main reason for the deterioration of fungal growth; the main species involved are Aspergillus, Fusarium, and Penicillium [9]. Apart from the great economic losses generated by the presence of mold, another concern is the potential to produce mycotoxins that could cause public health problems. Molds yield and release millions of spores which is very tiny to air, water and insect-borne. Mycotoxin is one kind of toxic agents release by mold. It will bring a lot of side effects to human health. Inhalation of mycotoxin is around 10 times more toxic than systemic organisation (LD50 approximately 4.5 mg/kg) and around 20 times more toxic than dermal organisation (LD50 greater than 10 mg/kg) according to experiments that were conducted to study the acute inhalation toxicity of T-2 mycotoxin. The highest risk people are people who have respiratory allergies or bronchitis problem and infants, children, elderly people, and pregnant women [10].

The main tenacity of this study is to verify the effect of negative ions on prevention of mold growth on bread. Thus, an image is prepared in order to display and identify the time frame for each development stage of the experiment project. This project consists of two parts, experiment set up and image processing by using MATLAB. The main component of the project is MATLAB 2015b, bread, AC to DC converter, 12V DC fan and 12 V negative ion generator.

II. METHODOLOGY

A. Material and Method

This research was done by the research team from Universiti Malaysia Pahang. This study is justified with a loaf of bread. The sample of this study is based on the effects of molds with air ventilation and negative ion generator. This study not focused in the analysis of texture and the ingredients of the bread as the colour of bread is the main element to determine its category.

The overall block diagram of image analysis for this research is shown in Figure 1. Digital image of each category

obtained from a digital camera (Panasonic Lumix 16 MegaPixel). Twenty pictures for each container category name as No DC Fan, Negative Ion Generator with no DC Fan, DC Fan, Negative Ion Generator with DC Fan as in Figure 2 were captured and these images stored in the high-speed Personal Computer storage.

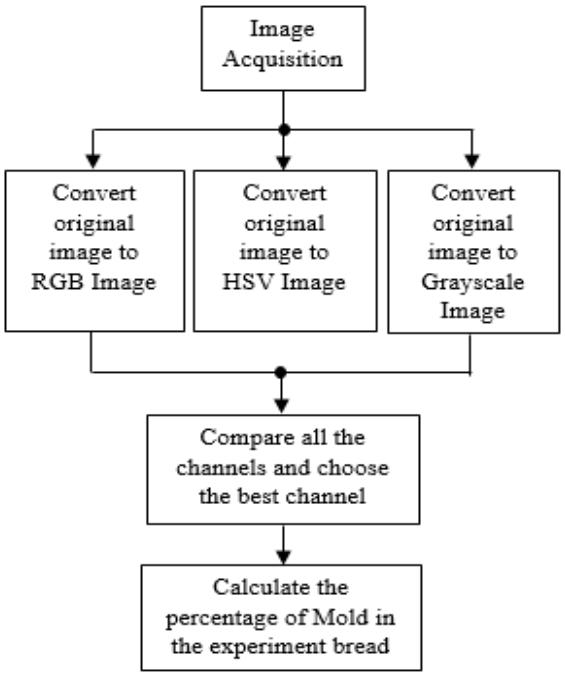
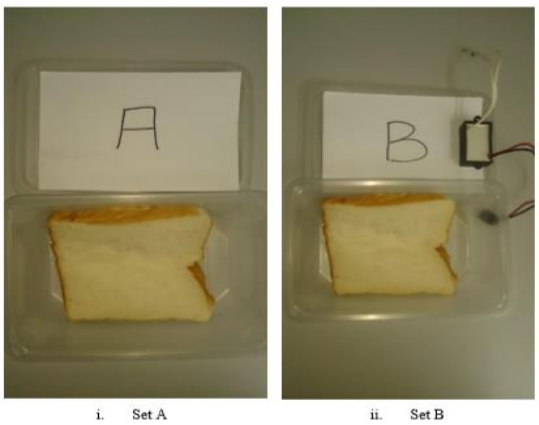
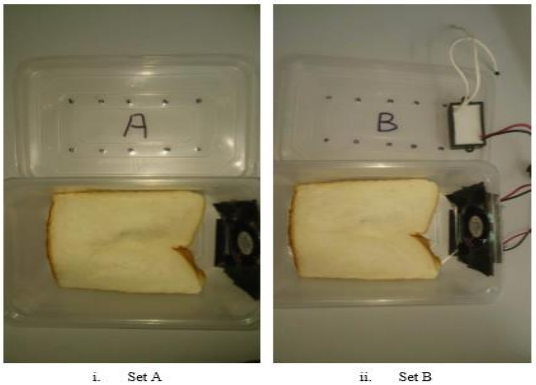


Figure 1: The block diagram of image analysis



(a)



(b)

Figure 2: The setup experiment images containers. (a) Set 1: i. Set A - No DC Fan, ii. Set B - Negative Ion Generator with no DC Fan (b) Set 2: i. Set A - DC Fan, ii. Set B - Negative Ion Generator with DC Fan.

B. Image Processing Tools

In this study, MATLAB 2015b is main software used for the detection of mold on bread negative ion generator. After the process of image acquisition, MATLAB 2015b will process of image and convert it to several channels. The channels involved are Red, Green, Blue, Hues, Saturation, Values and Grayscale.

C. Conversion of RGB of Hues, Saturation and Values

The R, G, B values are divided by 255 to change the range from 0 to 255 or 0 to 1[11]:

$$\begin{aligned} R' &= \frac{R}{255} \\ G' &= \frac{G}{255} \\ B' &= \frac{B}{255} \\ C_{\max} &= \max(R', G', B') \\ C_{\min} &= \min(R', G', B') \\ \Delta &= C_{\max} - C_{\min} \end{aligned} \tag{1}$$

Hue calculation:

$$H = \begin{cases} 0^o, \Delta = 0 \\ 60^o \times \left(\frac{B' - R'}{\Delta} \bmod 6 \right), C_{\max} = R' \\ 60^o \times \left(\frac{B' - R'}{\Delta} + 2 \right), C_{\max} = G' \\ 60^o \times \left(\frac{B' - R'}{\Delta} + 4 \right), C_{\max} = B' \end{cases} \tag{2}$$

Saturation calculation:

$$S = \begin{cases} 0^o, C_{\max} = 0 \\ \frac{\Delta}{C_{\max}}, C_{\max} \neq 0 \end{cases} \tag{3}$$

Value calculation:

$$S = C_{\max} \tag{4}$$

D. Conversion of RGB to Grayscale

There are several methods to convert the RGB image to grayscale, lightness method, average method and luminosity method. The lightness method averages most visible and least protruding colours and average method simply averages the values is shown in Equation (5) and Equation (6) respectively [11].

$$\left(\frac{\max(R,G,B)+\min(R,G,B)}{2}\right) \quad (5)$$

$$\left(\frac{R+G+B}{2}\right) \quad (6)$$

The luminosity method is an erudite version of the average method. It also averages the values, but its formulas a weighted average to account for human awareness. The green colour is weighted most heavily because green colour can be sensed easily. The formula for luminosity is shown in Equation (7) [11]:

$$0.21R+0.72G+0.07B \quad (7)$$

E. Calculation of area of bread and mold

The area of bread is calculated in pixel square after the object has been extracted out from the original captured image. Then, the green color background of the original captured image will be removed to obtain the area of bread that use for the calculation of mold percentage.

The area of mold is calculated after the area of bread is calculated. From the area of bread, the threshold value of mold is set. By running our program in MATLAB 2015b, it will generate an area of mold according to the threshold value of mold.

F. Calculation of Mold Percentage

First, the area of bread is measured and recorded. Then, the area of mold is measured and recorded after the mold is detected. After that, all the value and data is recorded in a table. Equation (8) is the formula to calculate the percentage of mold:

$$\text{Mold}(\%)=\frac{\text{Area of mold (pixel square)}}{\text{Area of bread (pixel square)}}\times 100 \quad (8)$$

III. Result and Discussion

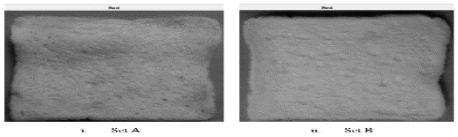
A. Result of Experiment for Set 1 and Set 2

The result of the experiment is displayed by comparing the channels of original, Red, Green, Blue, HSV, Hue, Saturation, Value and grayscale of bread. The differences are discussed and analyzed.

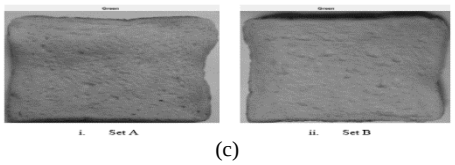
B. Result of Experiment for Set 1

Figure 3 shows the experiment results set for set 1 in a real situation. In set 1, the bread is put into the containers that not build with 12V DC fan. The experiment is separated into two sets, set A is control set which does not expose to negative ions and set B is set that exposed to negative ions. Figure 3 shows the original, Red, Green, Blue, HSV, Hue, Saturation, Value and Grayscale of bread from experiment set A and experiment set B.

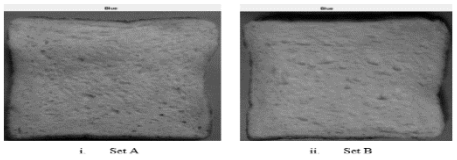
(a)



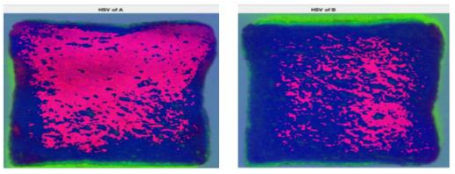
(b)



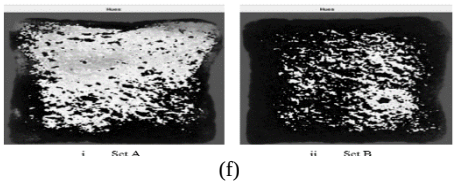
(c)



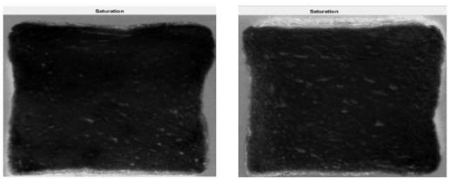
(d)



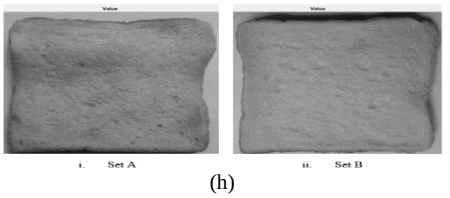
(e)



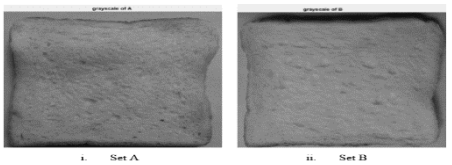
(f)



(g)



(h)

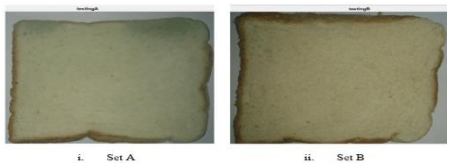


(i)

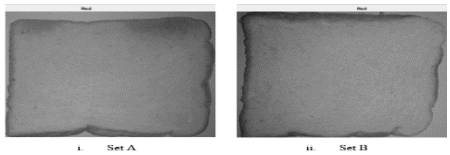
Figure 3: Comparison of Set A and Set B for experiment 1. (a) Original image, (b) Red channel, (c) Green channel, (d) Blue Channel, (e) HSV channel, (f) Hues channel, (g) Saturation channel, (h) Values channel, (i) Grayscale channel.

C. Result of Experiment for Set 2

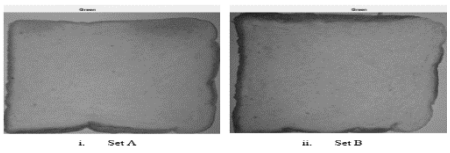
In set 2, the bread is put into the containers that build with 12V DC fan. The experiment as in Figure 4 is separated into two sets, set A is control set which does not expose to negative ions and set B is set that exposed to negative ions. Figure 4 shows the original, Red, Green, Blue, HSV, Hue, Saturation, Value and Grayscale of bread from experiment set A and experiment set B.



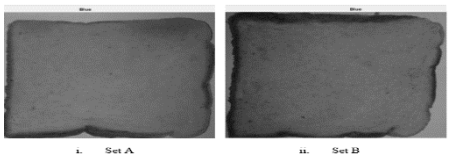
(a)



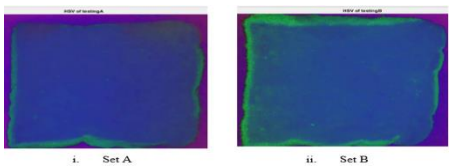
(b)



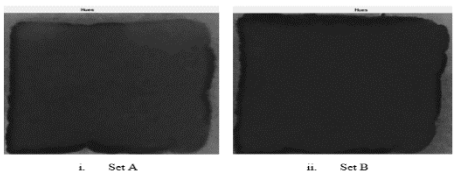
(c)



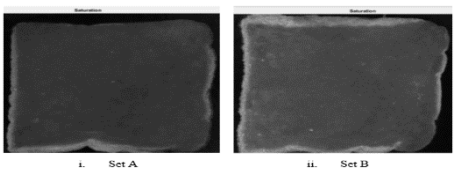
(d)



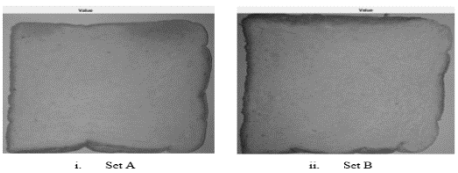
(e)



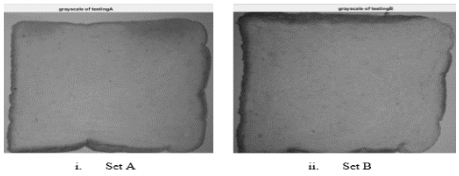
(f)



(g)



(h)



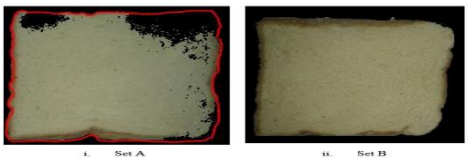
(i)

Figure 4: Comparison of Set A and Set B for experiment 2. (a) Original image, (b) Red channel, (c) Green channel, (d) Blue Channel, (e) HSV channel, (f) Hues channel, (g) Saturation channel, (h) Values channel, (i) Grayscale channel.

D. Result of Qualitative Analysis

From the 7 color channels, Hue channel showed the most significant proof after undergoing threshold detection of mold on the surface while the other channels do not show any important marking but the HSV channels perform better than RGB. Figure 5 shows the images of bread undergo threshold detection of mold on the surface.

(a)



(b)

Figure 5: Comparison of Set A and Set B (a) Set 1, (b) Set 2

Since the experiment is conducted in one-week time, a qualitative method is used to verify the effect of the negative ion on prevention of mold growth on bread. The portion of the mold in set A is more than in set B for both experiment set 1 and set 2.

E. Result of Quantitative Analysis

The percentage of mold on bread is calculated by using MATLAB2015b. Firstly, the area of bread is measured and recorded. Then, the area of mold is measured and recorded after the mold is detected. After that, all the value and data is recorded as in Table 1.

Table 1
Comparison of Mold Percentage for Set 1 and Set 2

S. No.	Set 1		Set 2	
Set	A without treatment	B with treatment	A without treatment	B with treatment
Area of bread (pixel square)	36522	37478	35001	34025
Area of mold (pixel square)	5334	1300	4963	400
Percent of mold (%)	14.60	3.47	14.18	1.18

From Table 1, the calculated percentage of mold in set 1(A) is 14.60% while in set 2(A) is 14.18%. The difference between set 1(A) and set 2(A) is 0.42%. The calculated percentage of mold in set 1(B) is 3.47% while in set 2(B) is

1.18%. The difference between set 1(A) and set 2(A) is 2.29%. The reason that causes the difference between set 1 and set 2 is air ventilation of experiment set up.

IV. CONCLUSION

In this paper, experiments have been conducted to verify the effectiveness of negative ions treatment on prevention of mold growth on bread. It used high voltage negative ion generator with a 12V fan as a ventilation. Investigation on the visibility of the mold was using color image processing in RGB, HSV and grayscale color channel. The results show that Hue channel is most effective because it showed a grey color instead of black color in Set 1 while in Set 2, it showed pale grey color. The effectiveness of negative ions on prevention of mold growth was successfully measured using qualitative and quantitative analysis.

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