A Comparison on Fish Freshness Determination Method

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Abstract—**Basically, freshness contributes a major factor to quality of fishery products. Several methods have been used to measure fish freshness which are sensory analysis, chemical method and physical method. The aim of the study is to make a comparison between fish freshness meter and quantification of RGB color indices in order to detect fish freshness. The sensor used in this study is Torrymeter which would measure three types of species while quantification of RGB color is focused on the fish eyes and gills.**

Keywords-component; fish freshness; RGB color extraction; digital image processing.

I. INTRODUCTION

Fish freshness is the main factor in the quality determination of fishery products by consumers. Commonly, after the fish dies, fish muscles will undergo alteration where sensory characteristic will change according to the number of organisms on the skin flesh and skin. These will result in a progressive lost of food characteristic in terms of taste, appearance and a general concept of quality [1].

Spoilage happened after a fish dies and its flesh begins to rot and would produce harmful substance that can affect its consumer. There are two major agents of spoilage which are bacteria and enzymes. These would grow immediately after the fish dies especially in warm and humid conditions, its habitat is polluted, is handled without care or stored at high temperature [2]. Enzymes that are present in the muscles, gut of the fish and organ are proteins that help to speed up processes such as digestion. The enzyme would still be functioning even after the fish dies that would contribute changes in the freshness.

Consuming spoiled fish leads to seafood poisoning and the consumer might encounter headache, sweating and dizziness, stomach ache, diarrhea, limb numbness, lower blood pressure and nausea. This seafood poisoning is known as scromboid poisoning, where it is generally related with high level of histamine in the spoiled fish [3]. Histamine is produced in fish by the action of bacterial decarboxylase enzymes on the amino-acid histidine and the enzyme is capable to grow and produce histamine over a wide temperature range above 4°C. Freezing the fish would only inactivate the enzyme but it continues producing histamine rapidly after thawing [4]. Once histamine is formed, it cannot be eliminated by heat, freezing, canning and retorting processes [5].

Different studies from different perspectives has been developed regarding on fish's quality determination as its characteristic of low commercial life, high variability and enormous marketable species leads to a difficulty to apply the same system used in other foods [6]. Therefore fish quality measurement is improvised each year with various methods to get a precise measurement. Chemical methods are usually more precise but they are time-consuming and expensive, so, electrical testers is often used because their immediate response.

In this study, there are two methods used to detect fish freshness which are Torrymeter and quantification of RGB color indices. Torrymeter manipulates the dielectric properties existed in the fish skin and muscle alteration systematically as the tissue component degraded while quantification of RGB colors where the mean values of RGB reflectance color space characterize and relate with qualities of fish.

This study also includes a comparison between species of fish which are mackerel, torpedo scad and soldier croaker as spoilage rate would be different to each of species based on its appearance, fat content, thickness of its flesh, its skin and gills.

II. SCOPE OF WORK

The scope of this study is to evaluate the relationship between fish freshness from various species by using Torrymeter and to compare Torrymeter and RGB color indices in determination of fish freshness. The main objective of this study is to analyze data collected to search a possible improvement to determine fish freshness and also to evaluate different species that can stand spoilage.

A. Equipment description (Torrymeter)

Torrymeter is an instrument used to measure fish freshness where it consists of two pairs of concentrically arranged electrodes. An alternating current is passed through the fish between the outer pair of electrodes and the voltage sensed by the inner pair [7]. There are two types of scale provided to indicate the fish freshness, which are 1 to 16 and 0 to 100.

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(a)

(b)

(c)

Fig.1

Fig. 1 shows the Torrymeter where (a) is the LCD display to show the reading, (b) is the sensing head which consist of two pairs of concentrically arranged electrodes and (c) is the plane view that shows its read button and reset button.

The Torrymeter manipulates the dielectric properties existed in the fish skin and muscle alteration systematically as the tissue components degraded. It is strongly related with the rapid changes in odor, appearance, flavor and texture that happened to the fish during spoilage. Hence, the determination of the dielectric properties set a measurement of the fish freshness [9]. The basic signal conditioning system used in the Torrymeter as in Fig. 2:

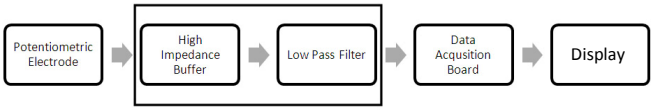


Fig. 2: Schematic diagram of measurement system

According to Fig 2 the sensing head is known as potentiometric electrodes which will be directly onto the fish skin. There are two auxiliary electrodes between the measuring electrodes where they are used to sense a proper contact with the fish. An alternating current is passed through the fish between the outer pair and the inner pair would sense the resulting voltage. The phase angle between the current and voltage is measured and converted to allow result on a convenient percentage in the range 0 – 100. The meter reading would decreases with spoilage. The meter would not harm the operator or affect the fish's condition as the current pass through the fish is only 1 miliampere. The meter reading would prevent readings under inappropriate situation e.g. in ice or in air. The second block shows that the system has very high input impedance and very low current of polarization is made with electrometric amplifiers LMC6001. The third block shows the active low pass filter is existed in order to eliminate the noise signals that come from electrical network. The forth block shows that the acquisition and digitalization of the data is made with the PCI-9112 and pass it to the display to show the meter reading [8]. Torrymeter can be connected to the computer to achieve the data gained. However, in this study, the data was taken manually on every fish for a better observation during experiment.

B. Equipment description (RGB color indices)

The RGB color model is made of three additive primaries – Red, Green and Blue. This model is used in CRT monitors and is device-dependent. The colors are called additive because these 3 different primaries can be added together to produce desired color. The color model is shown in Fig. 3 as a Cartesian cube where Red is the x-axis, Green is the y-axis and Blue is the z-axis.

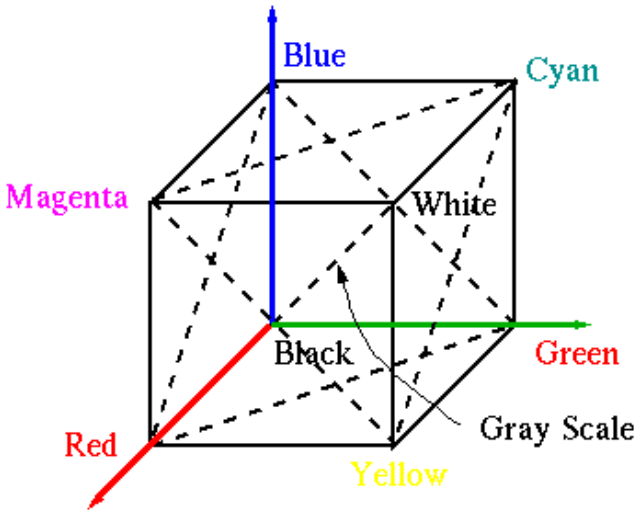


Fig. 3. RGB color cube

III. METHODOLOGY

Data were collected in 4 days where procedures have to be followed to gain accurate and precise measurements. The storage of the fish and their environment has to be observed to make sure any drastic result gained can be avoided.

A. Fish Samples

There are 90 samples of fresh fish that consist of three types of species are taken from Kuala Selangor. The species that involved in this study are;

i. Name: Soldier croaker
   Local name: Gelama
   Scientific name: *Johnius pseudociaerna soldado*
ii. Name: Torpedo scad
   Local name: Cencaru
   Scientific name: *Megalaspis cordyla*
iii. Name: Indian mackerel
   Local name: Kembung
   Scientific name: *Rastrelliger kanagurta*

The readings of these samples are taken on the first day of data collection before these samples are kept because these fish are still fresh. 15 samples of soldier croaker, torpedo scad and indian mackerel are placed into a container and they are stored in the freezer compartment. The rest 15 samples of soldier croaker, torpedo scad and indian mackerel are placed into another container and they are stored in the fridge compartment. The freezer compartment's temperature is set averagely at -14°C and the fridge compartment's temperature is set averagely at 4°C.

B. Measurement procedures using Torrymeter

The temperature of the freezer compartment, the fridge compartment, the laboratory and the fishes that kept in the freezer and the fridge are taken. When the fishes' temperature range are between 0°–10°, the measurement on fish freshness will be taken. The Torrymeter is calibrated before the readings are taken by using different samples of fish as a reference which consist of the freshest fish and the most spoilt fish to be tested. The sensing head of Torrymeter is placed firmly on the shoulder of the fish where it would lie flat against the surface and parallel to the lateral line as shown in Fig. 4.

Fig. 4: Appropriate way to measure using Torrymeter

A read button is used to achieve the reading and a value will be displayed at the LCD display. This procedure is repeated to each fish executed by three different persons to get the measurements. Every each day of data collection, the same process will be repeated where the sensing head will be placed at the same area of the fish as the reading would be variably different if the measurements are taken at different part of the fish. The process is continued until these fish are spoiled.

The Torrymeter's scale are set to 1 – 100 (Torry standard) where it can be interpreted as in TABLE I.

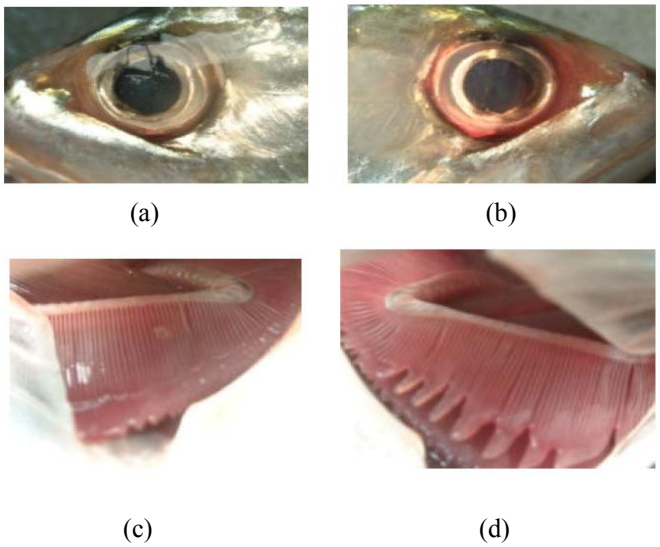
TABLE I. STANDARD RANGE OF FISH FRESHNESS

Condition	Reading value
Very fresh	more than 80
Fresh	between 60 to 79
Average	between 41 to 59
Spoiled	less than 40

Data taken is presented by comparing the freshness between species with different storage each day. The mean, max, min, standard deviation and variation of the data are observed.

C. Measurement procedures using RGB color indices

Two regions of interest (ROI) are chosen from each indian mackerel which are from fish eyes and gills. Fig. 5 shows the sample of ROI of the fish.



(a) (b)

(c) (d)

Fig. 5

Fig.5 shows the fish image with different area where (a) left eye (b) right eye (c) left gill and (d) right gill.

The Red, Green, Blue (RGB) component color images are acquired using FinePix 6900 Zoom (Fujifilm) digital camera, with pixel resolution of 2048x1536 and saved in JPEG format. The image capturing process had been done under standard and control environment in Image Capturing Studio Room (ICS Room) at Advanced Signal Processing (ASP) Research Lab, Faculty of Electrical Engineering, UiTM Shah Alam.

During the photo session, the camera is placed at a distance of half foot directly above the eyes and gills of fish (Fig. 5). The camera is placed at an angle of 55° of light setting. The lighting used to capture images is from a spotlight modeled Digicolor K-250C. The light intensity is controlled by Heavy Duty Light Meter (Model 407026) and Heavy Duty Data Logger (Model 380340). The recommended light measurement during calibrating has a mean lux of 1822 ± 21 for morning and 1824 ± 26 for evening session. During the photo session too, the lux values are taken by placing the Heavy Duty Light Meter connected to the Data Logger near the samples, It is to make sure that it follows the recommended lux value which is refer to morning (0800 to 1200) and evening (1400 to 1800) session, because the significant of p-value for lux reading for morning and evening is 0.555 as described in TABLE II.

TABLE II. PAIRED SAMPLE TEST IN MORNING, EVENING AND NIGHT SESSION

Paired Sample Test	P-Value
Morning - Evening	0.555
Morning - Night	0.002
Evening - Night	0.011

Every captured images are identified and the color of each pixel is expressed as an additive mixture of the three primaries of RGB bands. Once sample from each image is identified, its RGB mean pixel value will be recorded.

D Image Processing

One sample regions of interest (ROI) from each fish image were identified and the color of each pixel was expressed as an additive mixture of the three primary RGB bands [9].

Once sample from each image has been identified, its RGB mean pixel value will be recorded. Then, it will be analyzed using chosen statistical tools appropriate for this study using SPSS software.

E Filtering and Cropping Image

Using MATLAB software, this process done by create a command to filter and crop the images. There were artifacts such as small white ellipse lines or dots within the image which was recommended to remove using median filter technique [10].These artifacts can be considered as impulsive noise and can so be reduced using a median filter given by:

$$P_{med}(m,,n) = median\{P(m-k,n-1) \mid -\frac{N_{med}-1}{2} \le k,$$

$$l \le \frac{N_{med}-1}{2} \wedge 1 \le m-k \le m \wedge 1 \le n-1 \le N \ \} \qquad (1)$$

where N_{med} is odd[2] and indicates the size of the two dimensional median filter. P represents all the three color components. Note that only square median filter kernel was considered.

After the filtering process, region of interest (ROI) which includes a sample of fish images were recognized. After the regions of image have been recognized, they were cropped out sequentially with the first image and followed by the other image sample. In this case, all images of 22 samples from both freezer and fridge were cropped out. All samples were then been resized to a dimension of 50 x 50 pixel [11]. With this standardize of sample area, computation during quantification of color extraction become easier. Below is the flowchart of image processing.

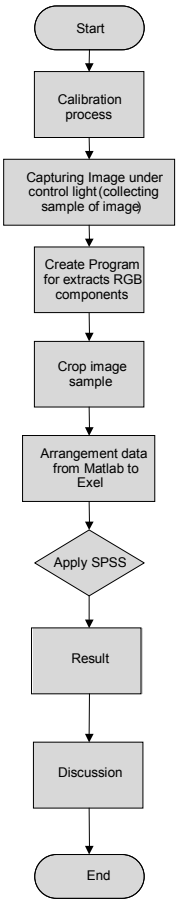


Figure 6 - Image processing flow chart

F Statistical Measurement

In this study, SPSS software is used to represent the data of RGB value after the data has been collected. By using this software, it is the easy way to present the data of RGB value by using graphical, tabulate and test method because most people cannot cope with large quantities of data. It can be seen in previous chapter in methodology where test method was used for data of lux. Paired Sample T Test was used to determine the best session for capturing fish images.

For the result, tabulate and graphical methods are used in order to show the mean value of RGB for each day. Mean refer to the sum measurements divided by the total number of measurements or observations. It is defined as the following [7]:

$$\overline{\chi} = \frac{\sum_{i=1}^{n} \chi_i}{n} \qquad (2)$$

Where n = number of observation

IV. Results and Discussion

Data (Torrymeter reading) collected are analyzed and plotted in line charts for a better interpretation where the collective freshness of fish samples for three different species for each day and varies by compartment is compared to days occurred. Next, data (RGB value) are analyzed in order to study the characteristic of fish freshness. The analysis is done by using SPSS software. The analysis is made to find a mean value for each basic color recorded before. The mean values plotted in a linear graph to give a better interpretation for observation.

The line chart below is divided into 4 colors which are Green (Very fresh) indicates 80% and above, Blue (fresh) indicates 60%-79%, Yellow (Average) indicates 41%-59% and Red (Unfit to eat) indicates below 40%.

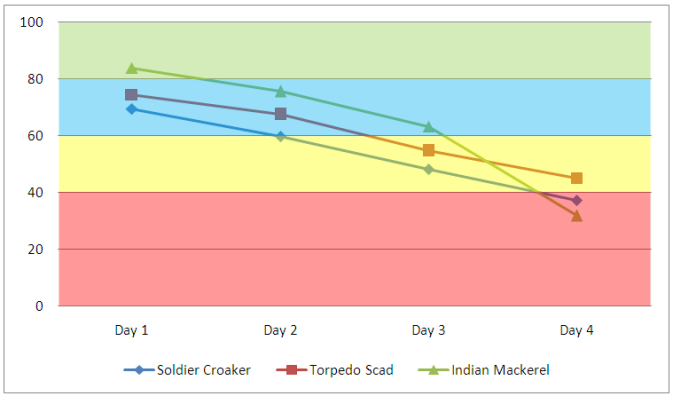


Fig. 7: Mean values versus days of fridge compartment

Fig. 7 shows the mean values of different type of species in fridge compartment in 4 days. It is observed that the indian mackerel deteriorated faster than the others. This probably because indian mackerel is a fatty fish which came from a scrombidae family, a common type that related to scromboid poisoning. Its skin is the thinnest among this three species which also lead to rapid deterioration.

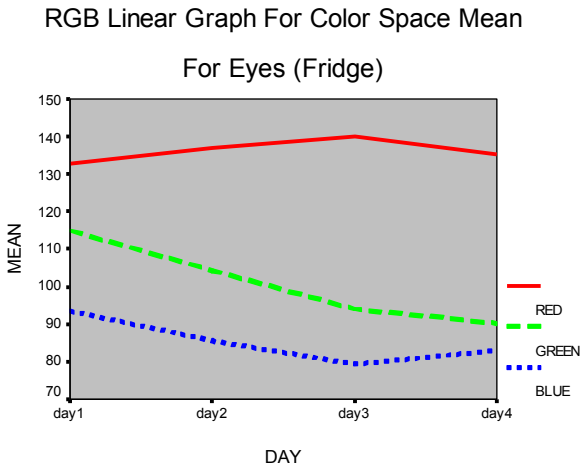


Fig. 8

RGB linear graph for eyes of fish in fridge compartment shows a cut-off point for Fig.8 can be determined in day 3. It is proved by the change of progress RGB line for day 3 and can be observed from the graph.

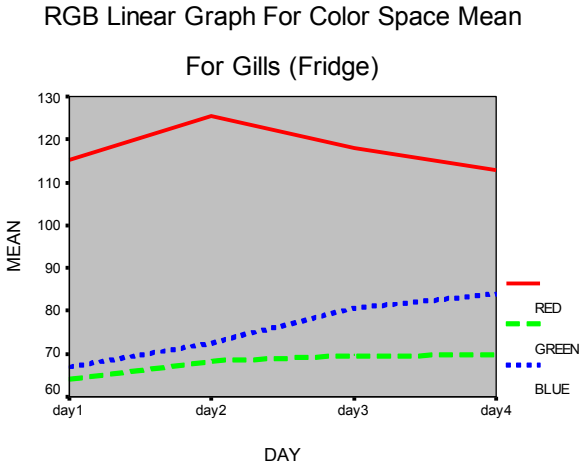


Fig. 9

RGB linear graph for gills of fish in fridge compartment shows a cut-off point for Fig. 9 can be determined in day 3. However the red color starts to cut off in day 2 while the green and blue colors initiated to change in day 3. The mean for red color in day 4 is slightly higher than day 1.

V. Conclusion

This work is intended to compare the fish species using Torrymeter and to compare detection method of fish freshness using Torrymeter and RGB color indices. In this study, it shows that indian mackerel deteriorated faster than torpedo scad and soldier croaker, therefore it is proved that variety of species have different level of deterioration where species are differed by their appearance, fat content and the skin thickness.

In comparison of Torrymeter usage and RGB color indices, Torrymeter shows the precise measurements for every data taken in a percentage scale while RGB color indices shows that the time for the fish freshness to deteriorate can be determined where the fish starts to spoil in day 3. Torrymeter's advantage is it shows rapid results and user friendly. Torrymeter also shows the precise measurement in a percentage scale but RGB color indices takes time and tedious to be done.

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