Non-destructive freshness assessment of *Cyprinus carpio* based on image analysis

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**Abstract.** Compared with existing chemical and microbiological analysis, image analysis as non-destructive quality assessment is promising a cheaper, faster process and also possible to capture data in real time. This study is aimed to determine the reliability of image analysis for assessing fish freshness in room temperature for 15 hours. Whole *Cyprinus carpio* were used as samples for image analysis, sensory analysis, chemical analysis (pH and TVBN) and microbiological analysis (TPC). Image analysis was focused on eye and gill. The results showed that fish freshness assessment using image analysis was in line with quality changes based on sensory, chemical and microbiological analysis. Image analysis of the eyes, showed that Value of HSV analysis and L of L, *a, *b analysis were increased. Image analysis of the gills showed that Hue, Saturation and Value of HSV analysis and *a and *b of L, *a, *b analysis were decreased while L* value was increased.

1. Introduction

Freshness assessments of fresh fish quality are commonly done with sensory, chemical and microbiological analysis. These conventional methods are reliable and recognized. Food quality assessment through image processing and analysis has been widely applied, but development of fish freshness assessment based on image analysis of fish eye and gill color has not been widely studied. This study was aimed to determine the value of *Cyprinus carpio* freshness by eye and gill color changes based image processing.

Image analysis method is one method that has been applied in various fields such as medicine, robotics, automotive industry, and many more. Usually, this method is used to replace human tasks that involve the senses of sight. This method also can be developed for knowing freshness of the fish from the color changes that occur in fish [1, 2]. This method has advantages than common method which is can work independently, objective, fast and cheap.

Digital color models for image processing have many choices. The color models are RGB, HSV, L *a *b, YCbCr, YIQ, YUV. In this study used HSV and L *a *b color space, HSV selected because sensitive to gradients discoloration [3], whereas the L *a *b chosen for color models that are commonly used to test color.

A study on the application of image processing to measure fish freshness has been done. Image processing research on changes in fish eye color and gills has been carried out by Dowlatti *et al.*, [4] in sea bream fish (*Sparus aurata*) which have a large size of eye. Image analysis research on whole fish has been done by Aguil *et al.*, [5] in milkfish. A study about image analysis on a change in the color of the eyes, gills and skin of fish had been carried out by Sengor *et al.*, [6] at sea bream (*Sparus aurata*) in cold temperatures for 18 days. The purpose of this study was to determine the pattern of decreasing freshness of goldfish during cold storage through pH, TPC, TVBN, organoleptic tests and through real-time image processing and to determine the correlation between the color model of the results of real-time image processing with the freshness test of fish tested conventional.
2. Methods

2.1. Material
3 Live *Cyprinus carpio* from Ambawara regency, Semarang were brought to Laboratory at Department of Fisheries Product Technology Faculty of Fisheries and Marine Science Diponegoro University. In the laboratory, live *Cyprinus carpio* stunned with chilled water and killed by piercing the brain. After these process, the fresh fish were ready for the research.

2.2. Research Process
Five Fresh *Cyprinus carpio* were stored at room temperature (28±1.4°C) for 15 hours. Fish flesh were collected every 5 hours for chemical (TVBN) and microbiological (TPC) analysis. Image analysis process every 5 minutes. Image analysis includes cropping, image conversion from RGB to HSV and L *a* *b*, color feature extraction, and storage to the database. Cropping is the process used to cut the image of the eyes and gills of fish. If this process is done so that the image formed only focuses on the eyes and gills of the fish and the other parts of fish will be removed. This method is considered effective in focusing images to be segmented [7].

![Image Analysis Apparatus](image análisis)

The HSV color model is obtained from the RGB transformation using the nonlinear transformation formula as shown in the following equation [8]:

\[ H = \begin{cases} \theta & \text{if } h \leq g \\ 360^\circ & \text{if } b > g \end{cases} \]

with,

\[ \theta = \cos^{-1} \left( \frac{\frac{1}{2}(r-g)+(r-b)}{|(r-g|^2+(r-g)(g-b))|^{1/2}} \right) \]

\[ v = \max(r, g, b) \]

\[ s = \frac{v-\min(r, g, b)}{v} \]

CIE L *a* *b* color model is obtained from a two-stage conversion from RGB to CIE XYZ using equation (3) then to the CIE L *a* *b* color model shown in equation (4) [9]:
The next process is the extraction of color features that are processed using MATLAB R2014b. Color feature extraction in question is to take the average value of hue, saturation, value, \( L \), \( a^* \), \( b^* \) from the cropping image area of the eyes and fish gills. The result of color feature extraction in the form of this number will be processed into a graph so that the pattern of each color component will be seen which will then be processed how the correlation of the color of the feature extraction results with the freshness of fish. Fish freshness test includes organoleptic [10] every hour, pH [11] every an hour, TVBN [12] conducted every five hours, TPC test [13] every five hours, and image analysis is carried out every five minutes.

3. Result

Result of this experiment indicates that the color of the gills tends to become brownish red while in the eye becomes yellowish white. The change of gills color value \( L, a^*, b^* \) show very strong correlation (or more than 85%) with fish freshness indicator than fish eye.

| Storage time (hour) | TPC (log CFU/g) | TVBN (mg N/100g) |
|--------------------|----------------|------------------|
| 0                  | 3.63 ± 0.33\(^a\) | 7.90 ± 2.50\(^a\) |
| 5                  | 4.21 ± 0.07\(^{ab}\) | 14.93 ± 0.64\(^b\) |
| 10                 | 4.65 ± 0.21\(^b\) | 14.93 ± 0.64\(^b\) |
| 15                 | 5.79 ± 0.26\(^c\) | 34.56 ± 3.96\(^c\) |

TVBN test on freshness of carp at room temperature showed a significant value at 0 to 15 hours. The increase in TVBN value caused by several factors, one of which was storage temperature.
According to Chudasama et al. [14] added that the increase in the value of TVBN caused by duration of storage.

Fish freshness divided into 4 criteria based on TVBN values. Fish with very fresh criteria, if the TVBN value is less than 10 mg N / 100 g. TVBN value between 10-20 mg N / 100 g included in fresh criteria. Fish with criteria are still suitable for consumption, if the TVBN value is between 20-30 mg N / 100 g and if the TVBN value is more than 30 mg N / 100 g, it is not suitable for consumption [15]. Based on these criteria, in this research carp with room temperature storage are no longer suitable for consumption after 15 hours in storage.

TPC test of carp freshness at room temperature show a significant increase at 0 to 15 hours. The increase in TPC value caused by several factors, one of which was the storage temperature. Temperature conditions and storage time have an effect on physicochemical properties, biogenic amine and total colonies [16, 17, 18]. Log TPC value of carp meat at the 15th hour in room temperature storage has exceeded the maximum limit that set in, the maximum value of fresh fish TPC is $5 \times 10^5$ CFU / g or equivalent to 5.70 CFU / g on the TPC log [19]. Microbes found in fish since harvested until processed during food preparation because of environmental condition [20]. One of the environmental conditions needed for life and growth of microorganisms is the appropriate temperature. When the temperature rises, the speed of metabolism rises and the growth of microorganisms is accelerated [21]. When fish are still alive, fish meat is normally sterile, but bacteria are present in the skin, gills, and guts [22]. When fish still alive, the growth and invasion of bacteria into the flesh of fish is prevented by the body's defense system. After the fish die, the fish's defense mechanism becomes damaged, the bacteria begin to multiply, and enter the meat. Bacterial activity is responsible for spoilage and affects shelf life [23].

![Graph showing organoleptic and pH values](image_url)

**Fig 2.** Organoleptic and pH of *Cyprinus carpio* during storage

Based on the graphic, pH value of carp at room temperature storage has decreased. Goldfish samples with room temperature treatment at 0 hours had a pH value of 6.87, while at the 15th hour the pH became 6.43. The decrease in pH that occurs at room temperature is because after the fish die, the blood circulation stops, oxygen supply decreases, resulting in the breakdown of glycogen to lactic
During deterioration of the quality process of decomposition of glycogen to lactic acid, the greater the amount of lactic acid contained in meat has an impact on the pH value which decreases [24, 25].

Based on the graphic, patterns of color changes in the image of carp gills stored at room temperature have a pattern with the value of H down, S down, and V down while the value of L goes up, *a goes down, and *b goes down. At 0 hour, the gills color is red while at the 15th hour the color of the gills turns dark brown. The result of this study was in accordance with Fazial et al., [26] which states that the gills undergo discoloration during storage. This can be caused by the gills that are
placed under the light for 15 hours oxidized so that it affects the color of the gills. The color changes of gill from bright red to dark brown associated with metmyoglobin formation [27].

![Image HSV of Eye](image1)
![Image L*a*b of Eye](image2)

Fig 4. HSV and L*a*b* of Eye during storage

| Table 3. Visual changes occur in the eye during storage |
|-------------------------------------------------------|
| Storage time (hour) | 0 | 5 | 10 | 15 |
|---------------------|---|---|----|----|
| Eyes               |   |   |    |    |
| H                  | -0.64 | -0.53 | 0.76 | 0.54 |
| S                  | -0.98* | -0.95 | 0.98* | 0.98* |
| V                  | 0.10** | 0.98* | -0.96* | -0.99* |
| L                  | 0.98* | 0.96* | -0.93 | -0.95 |
| *a                 | -0.90 | -0.82 | 0.99* | 0.82 |
| *b                 | 1.00** | 0.99* | -0.95 | -0.99* |

The pattern of color changes in the image of carp that kept at room temperature has a pattern with H values down, S down, and V up, while L values up, *a down, and *b up. At 0 hour the pupils are clear black with a shiny yellow cornea while at the 15th hour the pupil's color turns gray with the cornea turning turbid yellow. This is in accordance with Murakoshi et al., [28] the eye of a fish that has experienced a backward quality has the characteristics of a slightly sunken eyeball, pupils turn grayish.

| Table 4. Correlation between image analysis and fish freshness |
|---------------------------------------------------------------|
| Color changes | Color space | TVBN | TPC | pH | Organoleptic |
|----------------|-------------|------|-----|----|--------------|
| Eyes           | H           | -0.97* | -0.97* | 0.96* | 0.99         |
| Eyes           | S           | -0.96* | -0.91 | 0.98* | 0.92         |
| Gills          | H           | -0.97* | -0.97* | 0.96* | 0.99         |
| Gills          | S           | -0.96* | -0.91 | 0.98* | 0.92         |
Correlation results show a color space that correlates with all fish freshness tests at room temperature, value model in the eye and \(^*a\) in gills.

4. Conclusion
There were correlations between HSV and L\(^*a\)*b color image with changes in the quality of fresh *Cyprinus carpio*. Eyes correlate with value, while gills correlate with \(^*a\).

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