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Research Article

Comparison of Appearances and Color Indexes for Tempe with Different Packaging Using Digital Image Analysis

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Abstract

Appearance and color in tempe are change during the fermentation and would be the important factor in the consumer's purchase decision. The purpose of this study was to determine the influence of four packaging types (plastic, banana leaf, teak leaf, and waru leaves) to the appearances and color indexes during tempe fermentation. The digital image analysis was used to compared the tempe surface appearance and color between the samples up to 120 hours fermentation. The results showed that the use of different types of packaging affected the tempe appearance and color. Tempe packed with teak leaf more quickly decreased the value of L*, increase the value of b*, and increased the occurrence of black spots on the surface. The plastic gave the most stable color changes throughout tempe fermentation, followed by waru leaf, banana leaf, and teak leaf.

Keywords: *Tempe; Packaging; Digital Image Analysis; Appearance; Color*

Introduction

Tempe is a collective name for a sliceable mass of precooked fungal fermented soybeans bound together by the mycelium of a living mold (usually *Rhizopus* spp.). Tempe is a non-durable product due to the enzymatic activity of microbes. Raw tempe which was stored at room temperature, is better to be processed and consumed no more than 2 - 3 days. Tempe damage was characterized by uncompact white mycelium, foul, wet, slippery, and unevenly grown mushrooms [1].

The tempe packaging plays an important role in extending the shelf life. This is because packaging could regulate the oxygen supply and maintains temperature for the occurrence of tempe fermentation. In addition to affecting shelf life, the packaging can also provide its own tempe flavor. Currently, the most commonly used packaging materials for tempe are plastic and banana leaf. But there are still some tempe producers who use teak leaves and waru leaves to wrap tempe like in Yogyakarta and/or Central Java area.

Most of the studies that assessed color use tools such as spectrophotometers or colorimeters, like the Hunterlab, Gardner or Minolta instruments. A hand-held tristimulus reflectance colorimeter was used by Nunes., *et al*. [2] to measure the color change of the strawberry fruit. Colorimetric spectrophotometer was also used to observe the discoloration of fresh apple pieces [3]. The sensory testing was also often used to assess the appearance of the food products [4]. Portela and Cantwell [5] have used sensory panels to assess the color and appearance of fresh melon pieces. Over the past two decades, digital photography has become commonplace and very affordable for the

research community to document and show images or photographs. Digital cameras, together with image analysis software, have been used to analyze the color of food products [6,7].

The effects of the type of packaging to the appearance and color of tempe during the fermentation or storage is still not well documented, defining whether it will give the same appearance or not. The implementation of digital image analysis on food products provides advantages, not only can assess the color, but also able to assess its appearance. Then, the objective of this research was to compare the appearance and color indexes of tempe made with 4 different types of packaging (plastic, banana leaf, teak leaf, and waru leaf) using digital image analysis.

Material and Methods

Tempe preparation

Tempe was kindly supplied by At-Tempe, a local tempe producer in Yogyakarta. The tempe packaging was using four types of materials: plastic, banana (*Musa* sp) leaves, teak (*Tectona grandis linn* F) leaves, and waru (*Hibiscus tiliaceus*) leaves. The weight of soybean in each package was 110 grams. The thickness of soybean on each pack is about 1 cm. The size of each package of tempe was 9 × 12 cm. Tempe then was stored at room temperature (25 - 27°C) until the analysis.

Digital image analysis setup

The lighting system. To obtain the picture, the sample gets illuminated using 4 fluorescent lamps (Philips, TL-D Deluxe, Natural Daylight, 18W/865, Philips, Indonesia) with color temperature of 6500 K (D65, standard light source commonly used in food research) and the color-rendering index (Ra) approaches 85%. The four lamps (60 cm long) are arranged in such a way that they form a square, 45 cm above the sample and at an angle of 45 against the sample. In addition, each lamp has a cover as a light disperser and an electronic ballast to ensure a uniform illumination system (Figure 1).

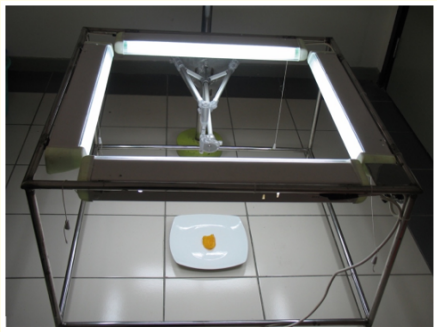

Figure 1: *The experimental setup of the lighting system, digital camera, and food sample.*

The Digital camera and image acquisition. A digital camera (Model Canon 550D, Canon Inc., Japan) was used by placing it vertically just above the sample at a distance of 20 cm. The angle between the camera lens and the light source revolves around 45. The image of one side of the tempe sample is taken by placing it on a dark background using the camera settings as follows: manual camera mode, ISO 100, shutter speed 1/60 seconds, aperture lens at F5.6, no flash, daylight conditions, with the images saved in memory card as RAW files (CCDRAW, non-compressed files).

Image analysis

The Adobe Photoshop CS3 Software (Adobe Systems Inc., San Jose, California) was use to obtain the color parameters from the digital images of tempe surface. The software was capable of displaying the color parameters L*, a*, b*, a model commonly used in food research.

The measurement or color analysis of the sample was based on what has been suggested by Papadakis., *et al* [6]. One of the tools in the Photoshop used in this research was Magic Wand Tool. The tool can choose certain area of an image, based on differences of the color, to be analyzed further. For example, it can select the dark or bright surface part of the sample, for which then measure L*, a*, b* and the precentage of the black surface. The selected image range is controlled with the tolerance value of the Magic Wand Tool, which is used for this research value 50. Tempe image was taken during the fermentation or storage at 48, 72, 97 and 120 hours, with 3 images taken for each sample.

Statistical analysis

To compare mean values, one-way ANOVA was used for color index and surface appearance. The Tukey-Kramer post hoc test was conducted when a significant effect was found by one-way ANOVA. Data analysis was performed using SPSS Statistics for Windows (version 16.0; IBM SPSS Statistics). Differences were considered as significantly different at $P < 0.05$.

Results and Discussion

Color indexes of tempe

Color is one important aspect that affects the consumer's acceptance of the product. The color analysis in this study was based on the values of L*, a* and b* on the sample of tempe with various variations of packaging and fermentation time.

No different was observed for the L* values of tempe packaged with the teak leaf, banana leaf and waru leaf, while the plasctic packaging resulted in the highest L* values (Figure 2). Except for the tempe with plastic packaging, fermentation time affected the L* values of tempe from the other groups. The L* values of tempe packaged with leaves showed a significant decline at 96 hours of fermentation and continued to declined at 120 hours. No difference was observed for the a* values of tempe using all types of packaging (Figure 3), however the teak leaf showed a significant high of b* values after 120 hours fermentation (Figure 4).

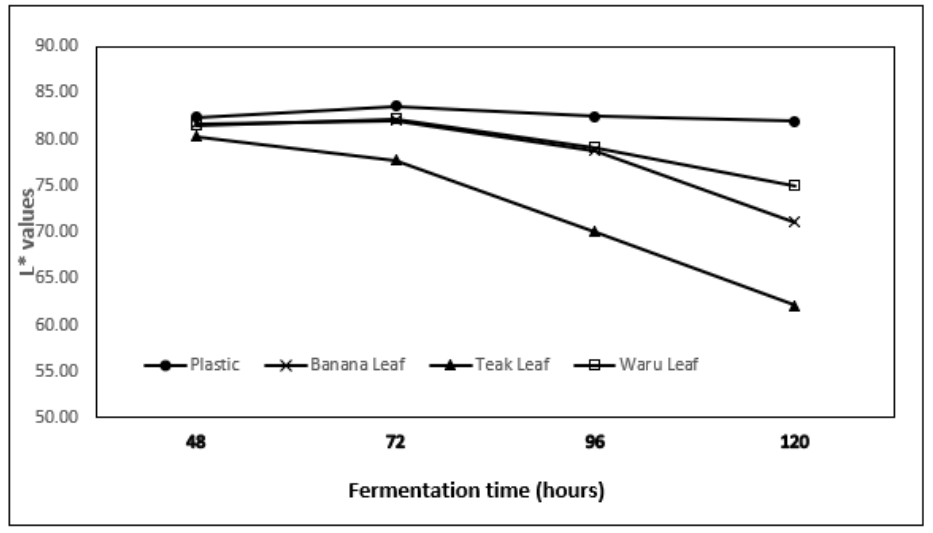

Figure 2: *L* mean values at different fermentation stage of tempe with different packaging during the fermentation at room temperature for 5 days.*

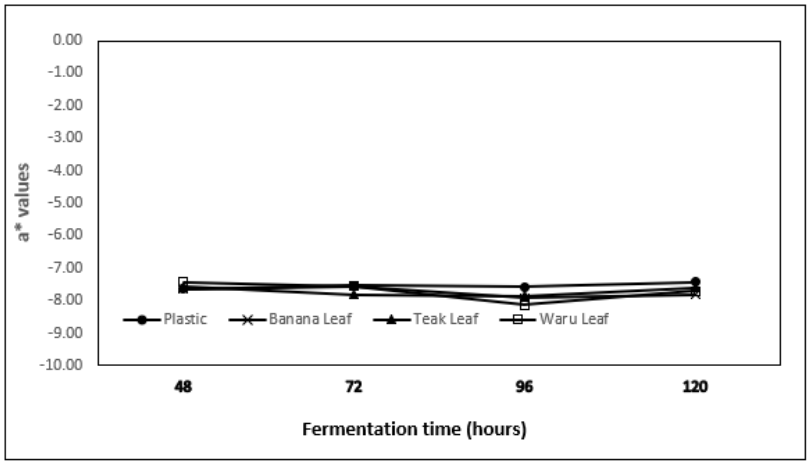

Figure 3: *a* mean values at different fermentation stage of tempe with different packaging during the fermentation at room temperature for 5 days.*

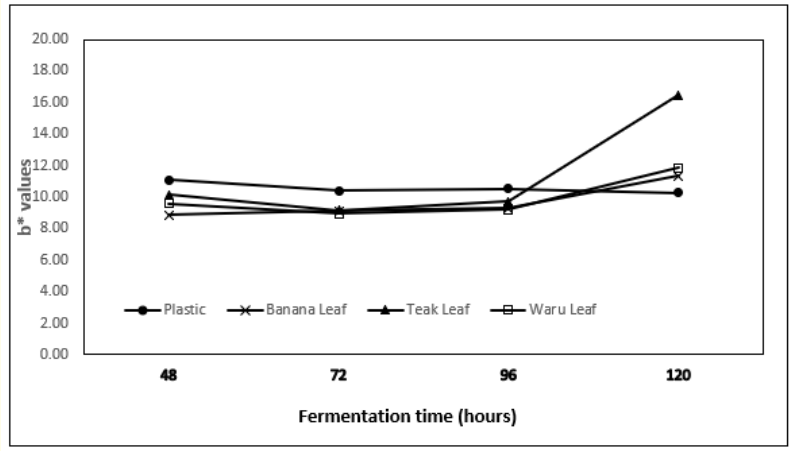

Figure 4: *b* mean values at different fermentation stage of tempe with different packaging during the fermentation at room temperature for 5 days.*

The whiteness of tempe packed with leaves (banana, teak, and waru) tend to decline fast due to mycelia which began to experience sporulation, causing black patches on the surface of tempe. In addition, on some parts of the tempe surface, the color begins to turn into a brownish yellow that may affect the measurement of the L* value of the sample. Another possible explanation was that the oxidation process during the fermentation could affect tempe to become darker. The fermentation process increased the production of unsaturated fatty acids of linoeat and linolenic acids. These fatty acids are susceptible to oxidative damage that can affect the color of tempe. Oxidation reactions not only damage the fatty acids themselves but also could damage the carotenoids, causing a dark color in tempe [8]. Compared to the plastic packaging, the packaging using leaves resulted in higher oxidation process, especially due to the intense contact with the oxygen surrounding the tempe.

The appearance of black spots in tempe

The duration of fermentation affects the quality of tempe, one of which resulted in appearance changes. If incubated in the long periods of time, at room temperature, tempe will be overgrown with gray spores or black on the tip and surface. This could decrease the quality of tempe's appearance.

The present study showed that with all types of packaging, long fermentation time increased the black spots on the surface of tempe (Figure 5). The teak-packaged tempe has the highest percentage of black spots compared to the other samples, while plastic-packed tempe has the lowest percentage of the black spots.

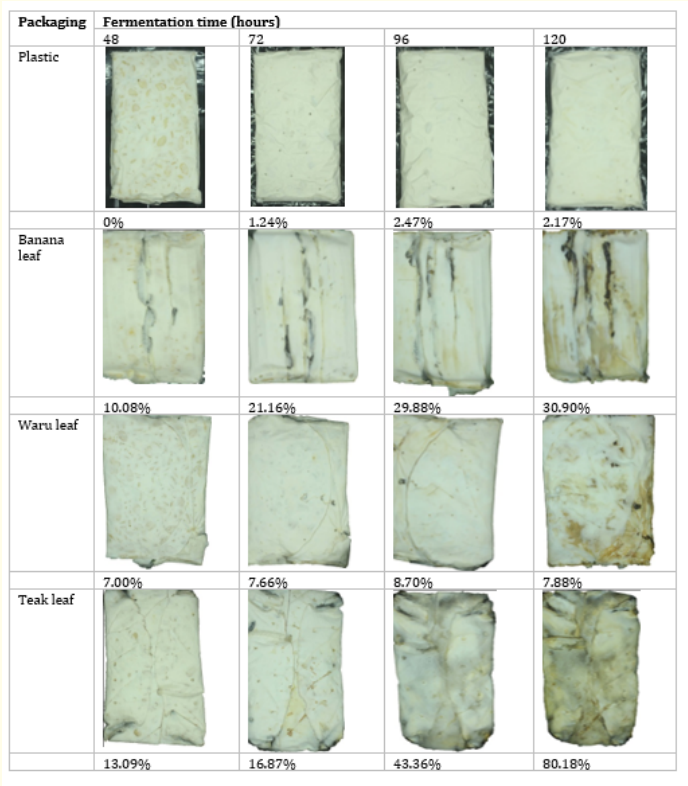

Figure 5: *The percentage of black area of tempe with different packaging during the fermentation at room temperature for 5 days.*

The black spots on the tempe surface as a result of tempe fungal sporulation caused by excessive aeration, extended fermentation, high temperature, and dry humidity. Tempe packed with teak leaves could be have greater intact with air, so the possibility of contact with oxygen was bigger, therefore the heat and water vapor were very easy to come out so that the humidity becomes low, causing a lot of black spots to appear on the surface of tempe. Meanwhile, the tempe packed with plastic has a good aeration because the perforation in the plastic with a distance of each hole 2 cm so that the possibility of sporulation of fungus was very small. Although the appearance of plastic-packed tempe was still good until the fermentation of 120 hours, but at 96 hours already resulted quiet stung smell, therefore it was recommended that tempe was better consumed before 96 hours.

Conclusion

Generally, the use of plastic packaging gives a more stable color and appearance of tempe, if we compared with leaves packaging (banana leaf, teak leaf, and waru leaf). Tempe packed with teak leaf more quickly decreased the value of L* (after 72 hours fermentation time), increase the value of b* and the occurrence of black spots on the surface (after 96 hours fermentation time). The use of digital image analysis can provide a more favorable assessment, with fast and easy to implemented especially for the appearances of food products.

Acknowledgements

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