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Sensitivity determination of indicator paper as smart packaging elements in monitoring meat freshness in cold temperature

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Sensitivity determination of indicator paper as smart packaging elements in monitoring meat freshness in cold temperature

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Abstract. Placing indicators on the packaging is a solution that can be used to monitor the quality of food packaged. The application of indicators to packaging technology is known as smart packaging. Filter paper is one paper that can be used as an intelligent packaging element that functions as an indicator because it can absorb pH indicator solutions that are applied to monitor the freshness of meat. The research objective was to make smart packaging indicators that have high sensitivity to amine compounds such as ammonia, indole, and cadaverine; thus, it can monitor the quality of meat stored at cold temperatures. The filter paper used was Whatman number 1 filter paper which soaked with pH indicators namely Phenol Red (PR); Phenol Red (PR) + Bromothymol Blue (BTB), and Bromothymol Blue (BTB). Smart packaging was applied to packaged fresh meat and stored in cold temperatures. During the storage, the results of the microbial and enzymatic decomposition of proteins and amino acids in fresh meat such as ammonia, indole and cadaverine compound accumulated in smart packaging indicators and cause color changes in the paper indicator. The results obtained indicated that the utilization of filter paper with PR + BTB immersion had a significant sensitivity of color change that can be used to observe changes in the quality of fresh meat stored in cold temperatures.

1. Introduction

Beef is very susceptible to damage because it contains high protein, 65-80%, water, nitrogen and fat that supports the growth of microorganisms, causing it to have a short shelf life and further affect the quality [1–3]. The rapid loss in the quality of fresh meat will be at risk to consumers and economic losses for producers [4]. This explanation is the reason for the need for supervision and quality control of fresh meat to prevent and monitor the microbial deterioration of fresh beef. In general, the method that can be done to monitor the quality of packaged meat is to look at the level of change in pH in meat or detected by changes in the color of meat or the aroma of packaged meat [5]. However, different perceptions of freshness standard cause difficulty in choosing fresh meat, especially packaged meat. Therefore it is necessary to develop packaging that can facilitate consumers in determining the freshness level of packaged meat.

Smart packaging is a packaging that has an indicator that can monitor the quality of packaged food [6–8]. Smart packaging indicators work by detecting the compound synthesized by microorganisms or enzymes that bound and accumulated in the indicator, causing color changes [9]. The utilization of smart packaging equipped with indicators is the most comfortable and most practical because it can be easily detected visually. PH-based indicator paper is a promising technology as it can detect both

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microbial and enzymatic metabolites in food products. Smart packaging indicators work based on changes in the pH of the food packaged, which results in color changes of the indicator [10].

Filter paper is one material that used as a material for making smart packaging indicators as it can absorb the color of the pH indicator. Smart packaging uses a pH indicator, previously applied to detect freshness in buffalo meat using the indicator bromophenol blue [11], Yolanda, (2018) used active and intelligent packaging in tuna, and Riyanto et al. (2014) applied smart indicators to detect the freshness of the Kurisi fish filet (*Nemipterus nematophorus*) [12,13]. Nevertheless, to date, the application of intelligent packaging indicators to food is still limited to food product stored at room temperature that motivates this study to identify the sensitivity of the indicator if applied in cold temperature.

Based on the explanation above, this study aimed to determine the potential of indicator paper as an intelligent packaging element by adding different pH indicators as the basis for making smart packaging indicators that can be applied to fresh meat stored at cold temperatures.

2. Methods

2.1. Materials

Materials used were Tenderloin meat obtained from Pammolongang Tamangapa Raya Slaughterhouse, Whatman number 1 filter paper, phenol red (PR) pH indicators, Bromothymol Blue (BTB) pH indicators, Styrofoam, and plastic wrap.

2.2. Solution indicator making

Indicator solution was made by dissolving 1% (w / v) of each pH indicator in 95% ethanol. Then the pH of each indicator solution adjusted using a solution of glacial acetic acid and NaOH and measured with pH meter (Horiba Laquatwin compact pH meter P-33) [6].

2.3. Smart packaging label making smart

Whatman paper No. 1 was cut in size 2 x 4 cm, then immersed in 10 ml of the indicator solution for 12 hours at a temperature of 28±2°C. Then the indicator label was dried for 10 minutes using a hairdryer (nanotech).

2.4. Smart packaging application on meat

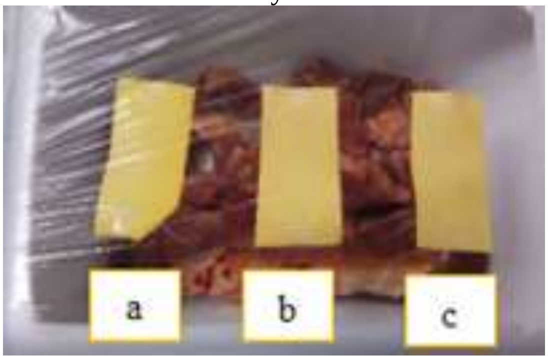
Fresh beef (tenderloin) with a normal pH (5.6-5.7) was obtained from the slaughterhouse of Makassar Tamangapa slaughterhouse taken at a relative postmortem time of about 5 hours, packed using a plastic container (polypropylene) and put in a cooler. Furthermore, the sample is prepared sterilely into 150-gram pieces/packaging. The pieces of meat are then packed in styrofoam (1.05 g/cm3) coated with active paper that fills the entire base of Styrofoam. Next, each indicator label then was placed in the packaging by attaching to the surface of the Low-Density Poly Ethylene (LDPE) film (0.9g/cm3) which was used as a cover. Samples were stored at cold temperatures (10 ± 1°C).

3. Results and discussion

Smart packaging is a packaging that embedded with an indicator thus it can directly monitor the freshness level and the quality of packaged food [6–8]. Smart packaging becomes a promising technology in the food industry as it can simplify consumer to determine the freshness level of a food product. In this study, smart packaging using indicator paper applied to monitor freshness changes in the beef product. The indicator was basically a paper contained a pH indicator that will change in color along with chemical changes (decay) that occur in beef during storage.

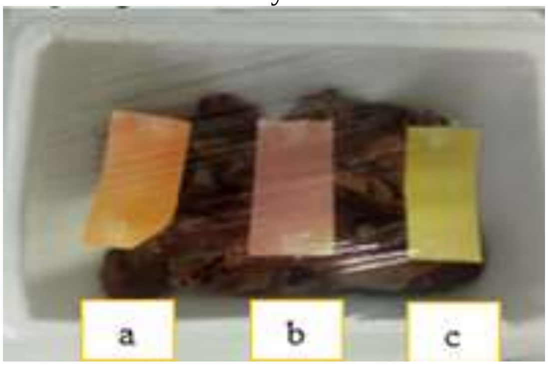
All paper immersed with each pH indicators were placed in the packaging and placed attacked to the packaging so that they can respond to the release of volatile acid as the metabolites of microorganisms in decomposing the meat during storage. During application, the packaging color of the indicator change along with the accumulation of the metabolite of microbes. Changing the color of the indicator is presented in Figure 1.

Change the Color of the Smart Indicator Label Day 0



Change the Color of the Smart Indicator Label Day 6

Change the Color of the Smart Indicator Label Day 9



Change the Color of the Smart Indicator Label Day 16

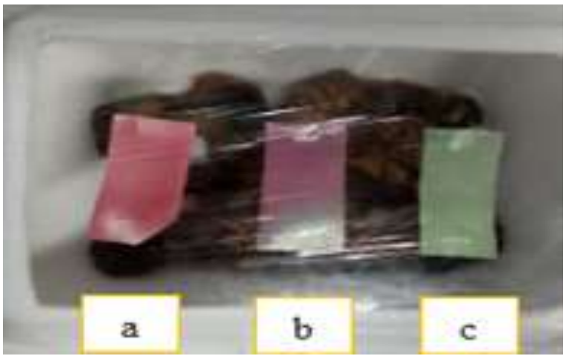


Figure 1. Change the Color of the Smart Indicator Label During Storage; (a) Phenol Red (PR), (b) Phenol Red (PR) + Bromothymol Blue (BTB) (1:1), and (c) Bromothymol Blue (BTB)

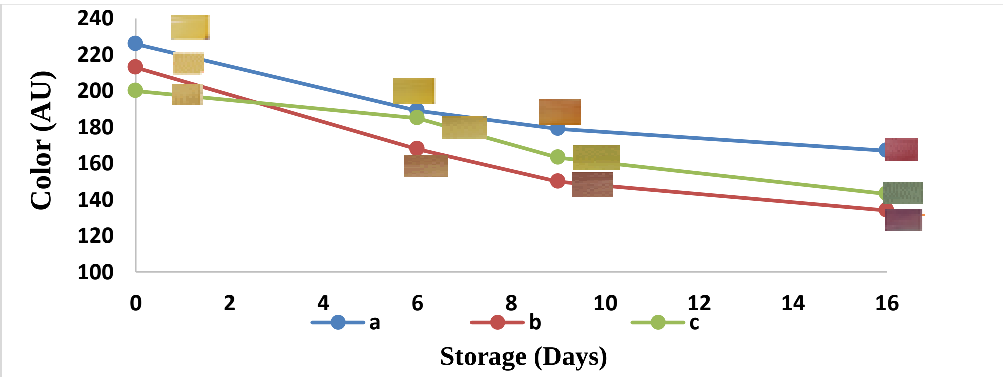


Figure 2. Indicator Color change profile during storage of meat (a) PR, (b) PR + BTB (1:1), and (c) BTB

Smart packaging indicators with various treatments were placed in packs and adjacent to meat product as the samples in this study to facilitate the process of sensoring amine compounds in packs that were regularly observed. Smart packaging indicators provide a significant color change response during storage in cold temperatures. The indicator color change rate was measured based on Red Green Blue (RGB) values. Based on the response obtained, the paper indicator label immersed in the combination of PR and BTB indicators set at pH 5 had a higher sensitivity and response to changes in meat quality (through color changes) compared to other indicators. The color change that occurs on the mentioned smart indicator had the most visually observable color change from yellow to red when the meat was in fresh condition and turned to purple when the meat had rotted and was no longer consumable.

Changes in indicators are followed by a decrease in the quality of packaged meat which can be seen in the storage of day 6 to 12; indicators changed in color to reddish-orange which was then followed by changes in color to purple on day 16 (figure 1). Color changes of indicators were caused by Total Volatile Bases Nitrogen (TVBN) formation and change pH on meat that accumulates on the packaging that detected by smart packaging indicators. TVBN compounds are the result of protein decomposition by the activity of bacteria and enzymes during the process of meat decay which causes a bad odor in the meat [14]. Linear correlation is shown in the length of storage of meat with a change in the color of the indicator that the longer the storage time of the meat, the clearer the color change in the packaging indicator becomes.

4. Conclusion

Based on the results of observations on the label of intelligent packaging indicators, bromothymol blue and phenol red combined with pH 5 have a sensitive color change to the decay of fresh meat stored in cold temperatures. The color change on the indicator label is clear on the sixth-day of storage and the indicator label change in color from reddish-orange to purple at the 16th day.

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