MELASTOMA MALABATHRICUM L. EXTRACTS-BASED INDICATOR FOR MONITORING SHRIMP FRESHNESS INTEGRATED WITH CLASSIFICATION TECHNOLOGY USING NEAREST NEIGHBOURS ALGORITHM

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Abstract
As a maritime country, shrimp commodity production in Indonesia is very high and continues to increase. However, because shrimp is a perishable food, we need a detection device. This is because conventional methods that are widely used by the community in detecting freshness of shrimp are only based on the smell. Of course, this is a problem when shrimp are packed in closed containers. In this paper, a method for detecting shrimp is proposed using the Melastoma malabathricum L. - based label indicator. The high content of flavonoids in the extracts allows the changing the colour of the label from red to grey due to the interaction between the label with the OH⁻ group that arises from the shrimp spoilage process. The colour that appears on the label indicator will correlate with the level of shrimp freshness. By increasing detection effectiveness, the classification is performed using the nearest-neighbours algorithm, which is equipped with an image processing mechanism in the form of colour quantization. There are four classifications used to express the quality of shrimp, namely "acceptable," "just acceptable," "unacceptable," and "more unacceptable." The accuracy of applying this method is 71.9%, with the majority of detection errors occurring in the "acceptable" class. Based on these results, it can be stated that the label indicators prepared in this study are very promising to be developed into intelligent packaging components.

INTRODUCTION

Shrimp is one of the leading fisheries commodities in Indonesia besides crabs, squid and fish. The total shrimp production in Indonesia continued to increase until it reached 585,000 tons in 2014 and with an increased rate of about 65% per year [1] [2]. Although it is highly sought after by consumers because of its very rich nutrition, shrimp are classified as perishable food [3] [4]. Bacterial activity in shrimp quickly reduces the quality of shrimp as indicated by changes in colour, smell, and taste until the spoilage process occurs. The spoilage of shrimps is also caused by poor handling resulting in decreased shelf life and nutritional value of shrimp [5] [6].

The mechanism that is generally used by the community to detect shrimp spoilage is through olfaction. However, this has the disadvantage that if shrimp are stored in a closed container, then the odour of the shrimp is not detected [7]. An alternative to overcome this is to use label indicators based on label colour changes because this method is easy and efficient to detect spoilage in all types of seafood, especially shrimp [8].

The indicators used in food packaging must be non-toxic and environmentally friendly. Currently, the development of indicator

materials has focused on developing label indicators from natural materials. Some natural ingredients that have been used as label indicators include *Ruellia simplex* [8], *Brassica Oleaceae extract* [9], and flower of *Bauhinia blakeana Dunn* [10]. But these plants are relatively difficult to obtain in coastal areas. One of the plants that have high survival and can potentially be used as an indicator of the freshness of shrimp is *Melastoma malabathricum L.* [7]. The deep purple colour of the fruit is an indication that it contains high flavonoids in the high amount [11] and it has the potential to detect shrimp freshness through the mechanism of colour change [12][13]. The colour change mechanism of the label indicator occurs due to the presence of OH$^-$ groups or changes in the pH of ammonia that appear as a byproduct of the decay process.

To improve the efficiency and accuracy of measurements, the label indicators developed in this study are integrated with artificial intelligence classification technology. The integration of artificial intelligence with label indicators to detect the freshness of shrimp is a new technique in food packaging. Some previous studies observed changes in the colour of the label with the manual image processing software [14] or UV-Vis spectrophotometer [15]. Thus, it is not simple. The artificial intelligence algorithm that will be applied is the nearest neighbours. We chose the nearest neighbours method because the method is simple and has good accuracy in image classification compared to several other methods such as neural-network [16] [17] and decision tree [18]. Integrating the label indicator with artificial intelligence technology is an effort to develop a system that can meet the challenges of the industrial revolution 4.0, which has entered various aspects of technology.

METHOD

This research method consists of two stages: (i) synthesis of label indicators from *M. Malabathricum L.* extracts, (ii) indicator sensitivity testing for shrimp freshness, and (iii) data processing using nearest neighbours algorithm. The method of label indicator synthesis carried out in this study refers to the synthesis of label indicators in previous studies [7]. The method of making label indicators based on *M. Malabathricum L.* extract is done by soaking Whatman paper on the extracts made from a mixture of ethanol and *M. Malabathricum L.* fruit under acidic conditions (pH = 2) and dried at room temperature.
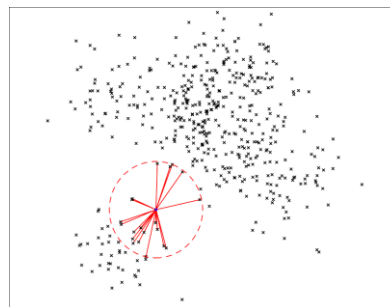

Figure 1. Nearest Neighours Algorithm

The label indicators created in this study have a red colour. The concept of nearest neighbours algorithm is illustrated in Figure 1.

Testing the detection of label indicator response to decay is done by storing shrimp in a glass container equipped with label indicators and then observing the colour change for up to 25 hours. Data processing using the nearest neighbours algorithm is done with Wolfram Mathematica 11.3 software using a computer with Intel Core i7-8750H (16 GB RAM) processor specifications. The use of Wolfram Mathematica software in this study is because the software can run a machine learning program and can be used to run a simple image processing algorithm [19] [20]. The nearest neighbours method is done using 27 training data. This method's accuracy level is determined automatically through Wolfram Mathematica software and validated by testing using 27 test data.

Before the image of label indicators is classified, the image obtained is quantized. It is intended that the colours obtained are consistent and the noise can be reduced. Colour quantization is a process of reducing the number of colours but still representing the image [21]. In this case, one type of colour is taken for each label indicator obtained. Classification of label indicators that will be carried out consists of classification: (i) acceptable, (ii) just acceptable, (iii) unacceptable, and (iv) more unacceptable. The determination of the classification is based on the organoleptic test results of shrimp based on the storage time function at room temperature carried out. The accuracy of the methods is determined by the ratio of correct predictions by the total predictions.

RESULTS AND DISCUSSIONS

After testing the response of the label indicator in detecting freshness of shrimp for 25 hours obtained information related to changes in the colour of the label indicator from red, purple, then grey. The testing method is done by putting the label indicator in a bottle containing shrimp as in Figure 2.

Figure 2. Measurement of label indicator performance

The colour change is related to the amount of ammonia gas released by the shrimp during the spoilage process. The longer the shrimp is stored (at room temperature), the more ammonia levels are released as a byproduct of the shrimp spoilage process. When matching shrimp quality data based on storage time based on research conducted by Ali et al. [21] then the relation of the colour of the label indicator with shrimp quality can be expressed by Figure 3.

"Acceptable" shrimp quality categories are indicated by red, "just acceptable" is shown by dark purple, "unacceptable" is indicated by light purple, and "more unacceptable" is indicated by grey. Through this image, it appears that the difference between unacceptable class and just acceptable class is quite challenging to observe.

In practice, the image of label indicators obtained from monitoring shrimp quality is not always homogeneous. Therefore, before classification with the nearest neighbours algorithm, the image of the label indicator is quantized into a single colour. In Figure 4, the results of the colour quantization of the indicator image and its image histogram are shown. It appears that before quantization, the colour distribution of the label indicator is scattered. However, after quantizing the primary colour of the indicator image is only focused on one value. Thus, the process of label indicator colour classification can run better.

Acceptable **Just Acceptable** **Unacceptable** **More Unacceptable**

Figure 3. Relationship of shrimp quality with indicator colours
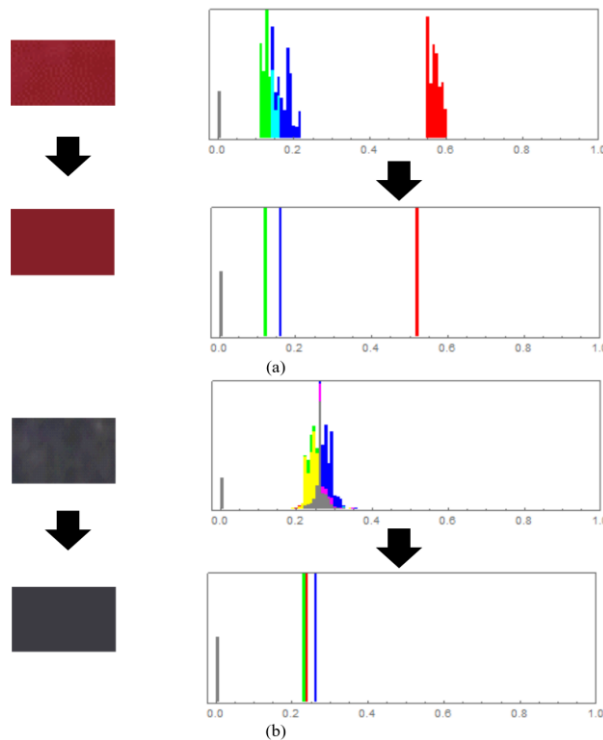
Figure 4. The results of the label indicator image quantization:
(a) for acceptable conditions; (b) for more unacceptable conditions

To measure the accuracy, the colour classification provided by the nearest neighbours algorithm, a comparison is made with the test data as in Table 1. It appears that from 27 tests, there were four times incompatible and 23 results that matched the test data. The majority of the inappropriate classification occurs on the acceptable quality of shrimp. This is caused by the almost similar image of the label indicator between the unacceptable quality and just acceptable quality. However, the increase in classification accuracy with nearest neighbours can be improved through the addition of training samples so that the classification system can better recognize the label indicator image. Also, based on the information data provided by the software in Figure 5, the classification system built in this study has an accuracy rate of 71.9% for a total of 27 training samples.

Table 1. Comparison of classifications based on organoleptic measurement and nearest neighbours predictions.

| No	Label Indicator of colour	Organoleptic classification	Nearest neighbours predictions
1.		Acceptable	Acceptable
2.		Acceptable	Acceptable
3.		Acceptable	Acceptable
4.		Acceptable	Acceptable
5.		Acceptable	Acceptable
6.		Acceptable	Acceptable
7.		Acceptable	Acceptable
8.		Acceptable	Acceptable
9.		Acceptable	Acceptable
10.		Acceptable	Acceptable
11.		Acceptable	Acceptable
12.		Acceptable	Acceptable
13.		Acceptable	Acceptable
14.		Acceptable	Acceptable
15.		Acceptable	Acceptable
16.		Just acceptable	Just acceptable
17.		Just acceptable	Just acceptable
18.		Just acceptable	Just acceptable
19.		Just acceptable	More unacceptable
20.		Just acceptable	Just acceptable
21.		Just acceptable	Just acceptable
22.		Unacceptable	Just acceptable
23.		Unacceptable	Just acceptable
24.		Unacceptable	More unacceptable
25.		More unacceptable	More unacceptable
26.		More unacceptable	More unacceptable
27.		More unacceptable	More unacceptable

Classifier information	
Input type	Image
Classes	A, JA, MU, U
Method	NearestNeighbors
Accuracy	71.9% + 6.2%
Loss	0.450 + 0.10
Single evaluation time	3.83 ms/example
Batch evaluation speed	1.43 examples/ms
Classifier memory	833. kB
Training examples used	27 examples
Training time	1.97 s

Figure 4. Information of the nearest neighbours classification system from the label indicator image

CONCLUSION

Indicator label based on *M. Malabathricum L.* extract can be used to observe shrimp quality based on the colourimetric method. Changes in shrimp quality followed by the release of ammonia gas will change the colour of the label indicator. Initially, the red label indicator then turns purple and grey when exposed to the OH^- group. Through the comparison between shrimp storage time and organoleptic quality, it is known that shrimp quality can be divided into four classes, namely: (i) acceptable shown by red, (ii) just acceptable shown by dark purple, (iii) unacceptable indicated by light purple and (iv) more unacceptable shown by grey. Through the classification of label indicator images using the nearest neighbours algorithm for 27 training samples obtained an accuracy rate of 71.9%. Also, according to 27 test samples got four classifications that did not match and 23 classifications that match to the database.

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REFERENCES

[1] N. Gusmawati, B. Soulard, N. Selmaoui, C. Proisy, A. Mustafa, R. L. Gendre, L. Thierry, L. Hugues, "Surveying shrimp aquaculture pond activity using multitemporal VHSR satellite images - case study from the Perancak estuary, Bali, Indonesia," *Marine Pollution Bulletin,* vol. 131, no. B, pp. 49-60, 2018. DOI: 10.1016/j.marpolbul.2017.03.059

[2] M. R. Dheanisa, T. Handayani, D. Susiloningtyas and N. S. Rahatiningtyas, "The relationship between shrimps production and mangrove ecosystem in Indramayu Regency," *IOP Conf. Series: Earth and Environmental Sciences,* vol. 429, p. 012055, 2020. DOI: 10.1088/1755-1315/ 429/1/012055

A. S. Eddin and R. Tahergorabi, "Applicatoin of a surimi-based coating to improve the quality attributes of shrimp during refrigerated storage," *Foods,* vol. 6, no. 9, pp. 76, 2017. DOI: 10.3390/foods6090076

[3] Y. Alparslan, C. Metin, H. H. Yapici, T. Baygar, A. Gunlu and T. Baygar, "Combined effect of orange peel essential oil and gelatin coating on the quality and shelf life of shrimps," *Journal of Food Safety and Food Quality-Archiv Fur Lebensmittelhygiene,* vol. 68, no. 3, pp. 69-78, 2017. DOI: 10.2376/ 0003-925X-68-69

[4] N. Gustina, K. Yuliati and S. D. Lestari, "Madu sebagai wet batter pada produk udang breaded," *J. Fishtech,* vol. 4, no. 1, pp. 37-45, 2015. DOI: 10.36706/ fishtech. v4i1.3497

[5] T. Ismail, R. Suleman, K. Akram, A. Hameed, I. U. Llah, M. Amir and S. Akhtar, "Pomegranate (Punica granatum L.) peel extracts inhibit microbial growth and lipid oxidation in minced shrimps stored at 4 C," *Journal of Aquatic Food Product Technology,* vol. 28, no. 1, pp. 84-92, 2019. DOI: 10.1080/10498850.2018.1561571

[6] A. Noor, J. Evi, S. Mustari, A. Aisyah, T. Fitri, and Y. Tiandho, "Senduduk (Melastoma malabathricum L.) extract as a green-indicator for monitoring shrimp freshness," *Advances in Engineering Research,* vol. 167, pp. 167-169, 2019. DOI: 10.2991/ icoma-18.2019.35

[7] A. Listyarini, W. Sholihah and C. Imawan, "A paper-based Colorimetric Indikator Label Using Natural Dye For Monitoring Shrimp Spoilage," *IOP Conference Series: Materials Science and Engineering,* vol. 367, pp. 012045, 2018. DOI: 10.1088/1757-899X/ 367/1/012045

[8] A. Khairunnisa, N. E. Suyatma and D. R. Adawiyah, "Label time-temperature indicator menggunakan campuran minyak nabati untuk memonitor mutu mikrobiologi susu pasteurisasi," *Jurnal Teknologi dan Industri Pangan,* vol. 29, no. 2, pp. 195-200, 2018. DOI: 10.6066/jtip.2018.29.2.195

[9] A. Listyarini, W. Sholihah, C. Imawan and R. Fitriani, "Colorimetri method by using natural dye for monitoring fish spoilage," *IEEE: 2017 International Seminar on Sensors, Instrumentation, Measurement and Metrology (ISSIMM),* 2017, pp. 141-145, DOI: 10.1109/ISSIMM.2017.8124279

[10] N. M. Sari, H. Kuspradini, R. Amirta and I. W. Kusuma, "Antioxidant activity of an invasive plant, Melastoma malabathricum and its potential as herbal tea product," *IOP Conf. Series: Earth and Environmental Sciences,* vol. 144, pp. 012029, 2018. DOI: 10.1088/1755-1315/144/1/012029

[11] J. Zhang, X. Zou, Z. X., X. Huang, C. Jiang and M. Holmes, "Preparation of an intelligent pH film based on biodegradable polymers and roselle anthocyanins for monitoring pork freshness," *Food Chemistry,* vol. 272, pp. 306-312, 2019. DOI: 10.1016/j.foodchem.2018.08.041

[12] G. Jiang, X. Hou, X. Zeng, C. Zhang, H. Wu, G. Shen, S. Li, Q. Luo, M. Li, X. Liu, A. Chen, Z. Wang, Z. Zhang, "Preparation and characterization of indicator films from carboxymethyl-cellulose/starch and purple sweet potato (Ipomoea batatas (L.) lam) anthocyanins for monitoring fish freshness," *International Journal of Biological Macromolecules,* vol. 143, pp. 359-372, 2020. DOI: 10.1016/j.ijbiomac.2019.12.024

[13] B. Kuswandi and A. Nurfawaidi, "On-package dual sensors label based on pH indicators for real-time monitoring of beef freshness," *Food Control*, vol. 82, pp. 91-100, 2017. DOI: 10.1016/j.foodcont.2017.06.028

[14] D. Yusufu, C. Wang and A. Mills, "Evaluation of an 'After Opening Freshness (AOF)' label for packaged ham," *Food Packaging and Shelf Life*, vol. 17, pp. 107-113, 2018. DOI: 10.1016/j.fpsl.2018.06.002

[15] M. Mustafa, M. N. Taib, Z. H. Murat and N. Sulaiman, "Comparison between KNN and ANN classification in brain balancing application via spectrogram image," *Journal of Computer Science & Computational Mathematics*, vol. 2, pp. 17-22, 2012. DOI: 10.20967/jcscm.2012.04.004

[16] A. El-Dahshan, T. Hosny and A. M. Salem, "Hybrid intelligent techniques for MRI brain images classification," *Digital Signal Processing*, vol. 20, pp. 433-441, 2010. DOI: 10.1016/j.dsp.2009.07.002

[17] S. Dreiseitl, L. Ohno-Machado, H. Kittler, S. Vinterbo, H. Billhardt and M. Binder, "A comparison of machine learning methods for the diagnosis of pigmented skin lesions," *Journal of Biomedical Informatics*, vol. 34, pp. 28-36, 2001. DOI: 10.1006/jbin. 2001. 1004

[18] Y. Tiandho, "Analisis kuantitatif pori berdasarkan pengolahan citra menggunakan Wolfram Mathematica," *KLIK: Kumpulan Jurnal Ilmu Komputer,* vol. 4, no. 1, pp. 15-23, 2017. DOI: 10.20527/klik.v4i1.65

[19] S. Meany, E. Eskew, R. Martinez-Castro and S. Jang, "Automated vehicle counting using image processing and machine learning," *Health Monitoring of Structural and Biological Systems,* vol. 10170, pp. 101703G, 2017. DOI: 10.1117/12.2261251

[20] R. V. Hemadri and R. K. Jatoth, "*Jaya Algorithm Based Intelligent Color Reduction,*" in Advanced Engineering Optimization Through Intelligent Techniques, Singapore: Springer, 2020, pp. 193-201, DOI: 10.1007/978-981-13-8196-6_18 ·

[21] M. Y. Ali, W. Sabbir, M. Rahi, M. Chowdhury and M. Faruque, "Quality changes in shrimp (Penaeus monodon) stored at ambient temperature in plastic and bamboo basket," *Interantional Journal of Animal & Fish Science,* vol. 1, no. 1, pp. 7-13, 2008.