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Original Research Article

Assessment of Skin Color Changes in Pineapple MD2 Using CIE L*a*b* Color Space

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Abstract: Pineapples serve as an excellent source of essential vitamins and minerals, and their consumption is predominantly in the fresh state due to the fruit's appealing taste. Harvesting pineapples based on skin color provides valuable insights into the ripening stages of the fruit. This study aims to non-destructively assess pineapple skin color changes using CIE L* a* and b* color coordinates to identify significant changes in the maturity index color. Thirty-thirty-five MD2 pineapples were harvested at various maturity indices ranging from index 1 to index 7, according to the Malaysian Pineapple Industry Board (MPIB) index class. The pineapple skin color changes were evaluated using a colorimeter (Minolta Chromameter, Model CR400) at three equidistant fruit areas from the bottom, middle, and top. The analysis involved a one-way ANOVA, which revealed a significant difference in color parameters across the maturity indices. Furthermore, Tukey's Test HSD (p<0.005) highlighted a substantial shift in colors, particularly in the a* (greenness) and b* (yellowness) values, from index 1 to index 7. This study aids in developing non-destructive technology for grading and quality inspection of MD2 pineapple.

Keywords: Non-destructive; Pineapple; RGB; Maturity Index

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1. Introduction

Agriculture is the primary economic sector in a nation's development (Kaur & Sharma, 2015). Fruits and vegetables are a great source of the vitamins and minerals that keep the human body healthy. Pineapples (Ananas comusus) are widely produced in tropical and subtropical climates across the world because of the temperate climate and spread of rainfall (Mohd Ali *et al*., 2020). Pineapple is a popular food choice among customers because of its delicious scent and rich nutritional value (Mohd Ali *et al*., 2022). Malaysia primarily grows pineapple varieties like Moris, N36, Sarawak, Gandee, Yankee, Josapine, Maspine, and MD2. Some cultivars, such as Josapine and N36, were created locally for the fresh fruit market (Lasekan & Hussein, 2018). The majority of people enjoy eating fresh pineapple.

MD2 is a variety of pineapple known for its distinct sweetness, consistent size, and ripeness when fresh. The Smooth Cayenne PRI hybrids 58-1184 and 59-443 are bred to create the MD2 cultivar of pineapple hybrid varieties (Siti Rashima *et al*., 2019). MD2 is also known as "Golden Ripe," "Super Sweet," or "Gold. It has various advantages over other pineapple varieties, such as a uniform bright gold color, sweeter taste, four times more vitamin C, less fiber, lower acidity, a thinner peel, and longer shelf life. Due to its exceptional taste, planting MD2 pineapple can yield up to three times more income (Thalip *et al.*, 2015). These are the main drivers that have encouraged pineapple growers to cultivate MD2. In terms of site preparation, cultural practices, final harvesting, and planting, MD2 is like other pineapple cultivars.

The demand for premium fruit is growing, making the development of non-destructive technology critical. Researchers in the food and agriculture sectors have developed various strategies to address traditional approaches' drawbacks to evaluating fruit quality. Non-destructive technologies have been employed to mitigate product quality concerns and enhance analytical techniques. Non-destructive testing involves harmless testing of fruit surfaces without damaging the fruit. The non-destructive methods depend on the food's mechanical, chemical, structural, and physical characteristics. Many non-destructive methods, including red, green, and blue (RGB) imaging, hyperspectral and multispectral imaging, electronic noses, computer vision systems, near-infrared spectroscopy, and visible spectroscopy, have been studied recently for fruit quality determination (Mohd Ali *et al*., 2023).

Different parameters such as ripeness, hardness, texture, and size might be considered when checking fruits and vegetables' quality. Fruit harvesting at various maturity indexes significantly affects the fruit's sensory quality. Pineapples ripen during plant growth but degrade slowly once harvested since they are non-climacteric fruits. To ensure optimal fruit quality, harvesting should be done at the ideal level of ripeness (Siti Rashima *et al*., 2019). The phases of ripeness are crucial as there is a high demand for fresh fruit. Therefore, it is necessary to investigate the non-destructive grading method to classify the maturity level of fruits for new market quality (Xu *et al*., 2022).

Numerous researches on non-destructive methods for grading pineapples have been conducted, emphasizing increasing fruit quality determination's efficiency and accuracy. Methods like near-infrared (NIR) spectroscopy (Qiu *et al*., 2023), image processing (Arboleda *et al*., 2021), and electric nose (Hasan *et al*., 2020) have been used to examine pineapples' internal and external features. Traditional inspections are still used by specialists with many years of experience to complete conventional inspections (Ullah *et al*., 2018). The grading involves identifying and classifying their maturity level based on external qualities like size, color, weight, or shape (Mohammad *et al*., 2012). Consequently, only specialist could apply their experiences to grade the pineapple. This technique could be inconsistent, ineffective, and time-consuming (Dittakan *et al*., 2018).

The Malaysia Pineapple Industry Board (MPIB) controls and develops the pineapple industry in Malaysia, from fresh to canned pineapple. Specifically, MPIB also has produced a ripening index chart for MD2 based on seven indices. The index describes the pineapple's skin color and indicates the fruit consumption's freshness level. To achieve the best quality and market value, it is essential to understand the complex color changes of MD2 pineapples during their ripening process for optimal harvest. Identifying the relationship between pineapples' color and their maturity index is essential to present their maturity and ripeness. Therefore, this study proposes to study the non-destructive technique for classifying pineapple ripening using a g colorimeter.

2. Materials and Methods

2.1. Fruit Samples

Thirty-five pineapple fruits from the m MD2 cultivar were harvested at ripening stage index one to seven from a local farm in Jitra, Kedah. The local supplier assessments on the pineapple maturity index were based on the Malaysian Pineapple Industry Board (MPIB) ripening chart as in Table 1. Five grade A pineapple fruits with uniform size and weight per maturity index were labeled and stored at room temperature for further processing. The skin assessments were conducted within 24 hours. The fruits were kept free from pests and damage to maintain their freshness and firmness.

Table 1. Maturity index for MD2 pineapple as described by MPIB

Index	Index Description	The sample acquired to match the index
1	Unripe fruit, dark green skin color Not suitable for fresh consumption	
2	Mature fruit Dark green skin color and slight yellow color at the base of the fruit Suitable to harvest for export sea shipping	
3	Fruit has ripened. The green color and one or two braktea have turned yellow at the fruit's base. Suitable to harvest for export by plane	
4	25% of the fruit has ripened, and the skin color has turned orange-yellowish Not suitable for export Suitable for local and fresh consumption	
5	50% of the fruits have ripened, and the skin color has turned orange-yellowish Best index for fresh consumption	
6	75% of the fruits have ripened, and the skin color has turned to orange-yellowish Suitable for local and fresh consumption	
7	Fruit is overripe, and almost 100% of skin color turned to yellow	

2.2. Skin Color Assessment and Analysis

The pineapple skin color changes were monitored at three different parts of the fruits. Measurements were taken at three equidistant positions around the equatorial part of the fruit using a colorimeter (Minolta Chromameter, Model CR400) as in Figure 2. Pineapple skin colors were measured three times for each position, and the results were averaged. The color changes were monitored using CIE L*a*b* coordinate systems where L* represents the lightness or brightness of the skin color, a* is the redness or greenness, and b* is yellowness or blueness.

Figure 1. Color measurement at three equidistant parts of the pineapple fruit.

To further evaluate the skin color changes, one-way ANOVA was performed to study the effects of the color parameters on the maturity index. Tukeys Test HSD was used to compare mean values of L*, a*, and b* to maturity index at significant (*p*<0.005) using XLSTAT (2021).

3. Results and Discussions

3.1. Descriptive Statistics of the Color Parameters

Table 2 indicates the descriptive statistics of the CIE L*a*b* color parameters. It is shown that there is a higher range of minimum and maximum values for L* and b* parameters as the fruit ripens from index 2 to index 6. This is explained by the skin color changes from green to yellowish orange, as observed on the pineapple skin. The ripening process starts from the bottom to the top of the pineapple.

Table 2. Descriptive statistics of the color measurements.

Index	Variable	Minimum	Maximum	Mean	Std. deviation
1	L*	37.64	43.78	40.44	±1.86
	a*	-2.66	-0.32	-1.75	±0.69
	b*	9.09	14.94	12.45	±1.91
2	L*	37.50	50.59	42.93	±3.54
	a*	-5.93	-0.70	-3.44	±1.53
	b*	12.63	26.21	17.78	±4.00
3	L*	43.02	51.29	47.51	±2.81
	a*	-6.21	0.41	-2.48	±2.13
	b*	18.04	28.79	23.67	±3.79
4	L*	41.43	53.03	46.39	±3.83
	a*	-3.18	5.75	0.39	±3.00
	b*	12.60	30.16	19.92	±5.22
5	L*	41.42	53.08	47.39	±3.57
	a*	-3.88	12.28	1.56	±4.56
	b*	13.66	44.54	23.47	±7.58
6	L*	41.87	55.20	48.56	±3.72
	a*	-4.91	4.88	0.74	±3.69
	b*	16.37	34.53	27.22	±4.50
7	L*	47.39	52.15	49.89	±1.57
	a*	6.47	12.29	10.25	±1.67
	b*	21.94	30.45	26.23	±2.77

3.2. ANOVA and Pairwise Comparison between Color Parameters and Maturity Index.

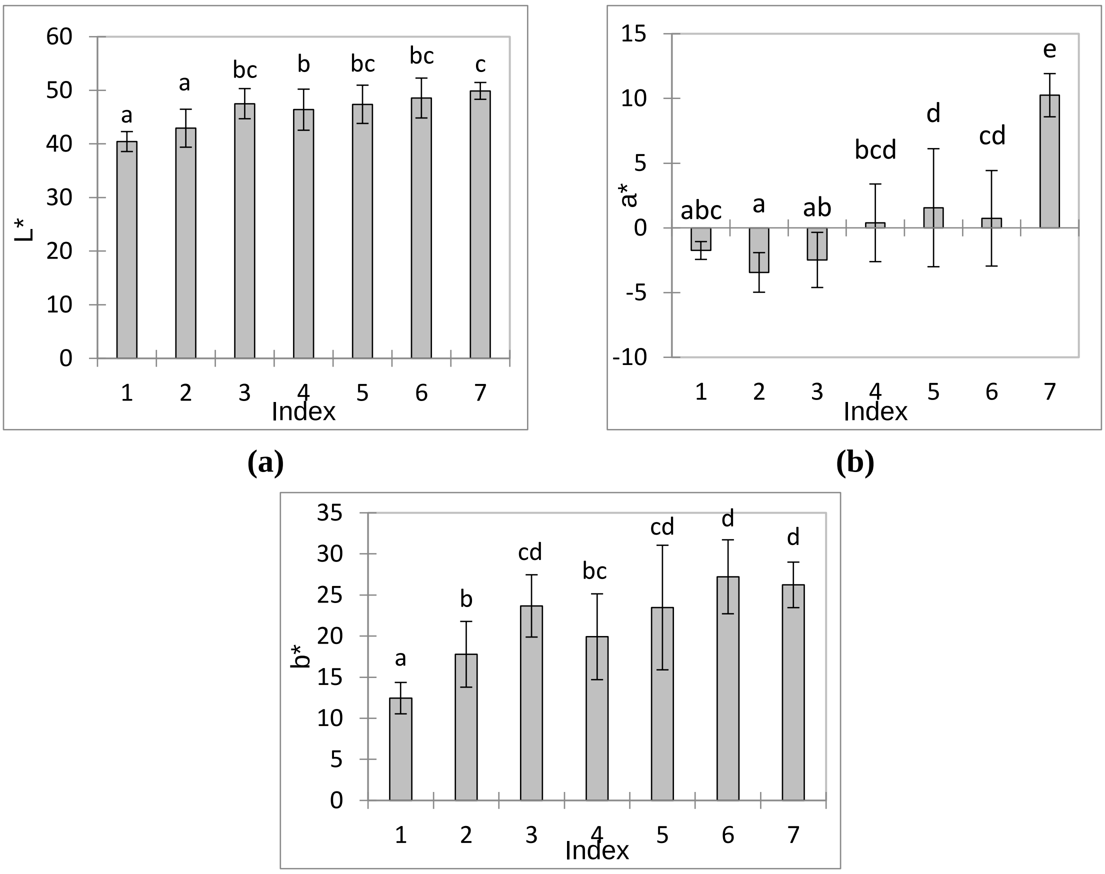
A one-way ANOVA was performed to compare the effect of the pineapple maturity index on the CIE Lab color parameters. A one-way ANOVA revealed that there was a statistically significant difference in the mean of L*, a*, and b* color parameters between the maturity index with F (6,98) F =17.129, p = <0.0001), F (6,98) F =40.980, p = <0.0001 and F (6,98) F= 19.331, p = <0.0001) respectively.

Figure 2 shows the results of the Tukey HSD pairwise comparison. Figure 2(a) indicates a significant difference in lightness as the maturity index shifts from index 1 to index 7. Index 1 and 2 show no differences in lightness values, similar to indexes 3, 4, 5 and 6. In index 7, the lightness significantly differs from the rest of the index, indicating lighter color values than index 1, which has darker values. Lightness shows light absorption with a value L equal to zero, indicating a black color.

Figure 2(b) shows the pairwise comparison for a*, indicating the skin color's redness or greenness. As observed, there is a rapid shift from dark green (-a*) to red (+a*), as indicated from index 1 to index 7. Index 1 to index 3 maintained the dark green color whilst rapidly changing to slightly red and red at index 4 to index 7. From index 1 to index 3, there is no significant difference when the values indicate -a* value, similar to index 4 to 6 when the color shifts to +a* values. The spike in index 7 shows the fruit has ripened and exhibits a high value of red color.

Figure 2(c) shows the b* color values, which indicate the increase in yellowness of the (+b*) color. The mean b* shows the increment of yellow value from index 1 to index seven, where indexes 1,2 and 6,7 showed significant differences. Tukey HSD shows an insignificant difference between index six and seven, as indicated by similar letters from the pairwise comparison.

The observation of the pineapple skin color changes is similar to the work of Ullah *et al.* (2018) using the pineapple variety Phulae (Queen), a geographical indication of Chiang Rai Province. The same observation on skin color changes was also found in a study by Lapcharoensuk *et al.* (2016), who studied the Smooth Cayenne variety from Chonburi Province, Thailand.



(c)

Figure 2. Pairwise comparison using Tukey HSD between color parameters and maturity indices for MD2 pineapple: (**a**) L*; (**b**) a*; **(c)** b*. Note: Mean sharing the same letter is not significantly ($p>0.05$) different from one.

4. Conclusions

This study was done to observe the skin color changes of the MD2 pineapple according to the ripening index chart provided by the MPIB using a colorimeter apparatus to aid in developing non-destructive technology for grading and quality inspection. In conclusion, significant differences are exhibited between the ripening index 1 and 7 for L*, a*, and b* color parameters. Further investigation revealed that there is a significant shift of colors as indicated by a* (greenness) value and b* (yellowness) from index 1 to index 7. Observing the right section of the pineapple fruit is crucial to guiding the right harvesting time and postharvest practice to ensure the freshness of the fruit.

Supplementary Materials: No supplementary materials.

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References

Arboleda, E. R., de Jesus, C. L. T., Tia, L. M. S. (2021). Pineapple maturity classifier using image processing and fuzzy logic. *IAES International Journal of Artificial Intelligence, 10*(4), 830–838. https://doi.org/10.11591/ijai.v10.i4.pp830-838

Dittakan, K., Theera-Ampornpunt, N., & Boodliam, P. (2018). Non-destructive grading of Pattavia Pineapple using texture analysis. *2018 21st International Symposium on Wireless Personal Multimedia Communications (WPMC)*. https://doi.org/10.1109/wpmc.2018.8713088

Hasan, M. A., Sarno, R., Sabilla, S. I. (2020). Optimizing machine learning parameters for classifying the sweetness of pineapple aroma using electronic nose. *International Journal of Intelligent Engineering and Systems, 13*(5), 122–132. https://doi.org/10.22266/ijies2020.1031.12

Kaur, M., & Sharma, R. (n.d.). Quality Detection of Fruits by Using ANN Technique. *IOSR Journal of Electronics and Communication Engineering, 10*(4), 35–41. https://doi.org/10.9790/2834-10423541

Lapcharoensuk, R., Aimwongsa, T., Kaeynok, A., *et al*. (2017). Color values models for determination of citric acid in pineapple. https://www.researchgate.net/publication/335518096

Lasekan, O., & Hussein, F. K. (2018). Classification of different pineapple varieties grown in Malaysia based on volatile fingerprinting and sensory analysis. *Chemistry Central Journal*, *12*(1). https://doi.org/10.1186/s13065-018-0505-3

Mohammad, S., Ghazali, K. H., Zan, N. C., *et al*. (2012). Classification of fresh N36 pineapple crop using image processing technique. *Advanced Materials Research, 418–420*(November 2015), 1739–1743. https://doi.org/10.4028/www.scientific.net/AMR.418-420.1739

Mohd Ali, M., Hashim, N., Abd Aziz, S., *et al*. (2020). Pineapple (Ananas comosus): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products. *Food Research International*, *137*. Elsevier Ltd. https://doi.org/10.1016/j.foodres.2020.109675

Mohd Ali, M., Hashim, N., Abd Aziz, S., *et al*. (2022). Characterisation of pineapple cultivars under different storage conditions using infrared thermal imaging coupled with machine learning algorithms. *Agriculture (Switzerland)*, *12*(7). https://doi.org/10.3390/agriculture12071013

Mohd Ali, M., Hashim, N., Bejo, S. K., *et al*. (2023). Innovative non-destructive technologies for quality monitoring of pineapples: Recent advances and applications. *Trends in Food Science and Technology*, *133*, 176–188. Elsevier Ltd. https://doi.org/10.1016/j.tifs.2023.02.005

Thalip, A. A., Tong, P. S., & Ng, C. (2015). The MD2 'super sweet'pineapple (Ananas comosus). *UTAR Agriculture Science Journal (UASJ)*, *1*(4).

Qiu, G., Lu, H., Wang, X., *et al*. (2023). Nondestructive detecting maturity of pineapples based on visible and near-infrared transmittance spectroscopy coupled with machine learning methodologies. *Horticulturae, 9*(8). https://doi.org/10.3390/horticulturae9080889

Siti Rashima, R., Maizura, M., Wan Nur Hafzan, W. M., *et al*. (2019). Physicochemical properties and sensory acceptability of pineapples of different varieties and stages of maturity. *Food Research*, *3*(5), 491–500. https://doi.org/10.26656/fr.2017.3(5).060

Ullah, H., Chaiwong, S., Saengrayap, R. (2018). *Application of image analysis for maturity classification of "Phulae" Pineapple.* The International Conference on Food and Applied Bioscience 2018 proceeding book. https://www.researchgate.net/publication/335754674

Xu, S., Ren, J., Lu, H., *et al*. (2022). Nondestructive detection and grading of flesh translucency in pineapples with visible and near-infrared spectroscopy. *Postharvest Biology and Technology*, *192*. https://doi.org/10.1016/j.postharvbio.2022.112029

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