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Evaluation of physicochemical properties of *Musa acuminate cv.* Berangan at different ripening stages

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Abstract

The physicochemical properties of *Musa Acuminata cv*. Berangan at different ripening stages (1, 2 and 3) were evaluated in the study. A visual attribute such as colour usually leads to misclassification as it can be subjected to different individual interpretation. Therefore, various measurements were conducted to determine the relationship between ripening stages and physicochemical properties of the fruit such as colour, pH, total soluble solids content (TSS) and firmness. Results showed that there were significant changes in physicochemical properties as ripening stages increased. Results also indicated that the correlations between ripening stages and firmness and pH values were statistically significant compared to other parameters. These relationships can be used to predict the related quality attributes of Berangan bananas.

Introduction

Definition of quality has been described by numerous perspectives that can be classified based on product and custom orientation. Fruit quality in terms of product orientation, can be viewed as the accessibility to distribute products through marketing chain by preserving the specific attributes such as sugar content, color or firmness, while, custom orientation defines quality in a much broader perspective as it depends on the complexity of the human needs and satisfactions (Shewfelt, 1999). For this reason, several studies were performed to describe the fruits acceptance and consumption by relating to how customers define the sensory attributes (Harker *et al*., 2003; Péneau *et al*., 2006; López *et al*., 2007; Harker *et al*., 2008). However, the relationship between customer acceptance and the quality related attributes is depends on the specific type and variety of fruit (Hoehn *et al*., 2003).

The fruit quality can be measured as a function of time, due to the continuous of physiological changes during fruit ripening, thus contributing to the development of evaluation using the empirical methods (Abbott, 1999). Despite, ethylene has been identified as the major hormone, in relation to specific genes, that participate in initiating the ripening process until the senescence of banana fruit (Bapat *et al*., 2010). The continuous and complex changes in physiological, biochemical and mechanical properties of fruits during the ripening process had been mostly influenced by the depolymerization of carbohydrate resulted in the degradation of cell wall structure (Prasanna *et al*., 2007). Subsequently, banana ripening can be predicted based on the transformation of the peel colour from dark green to deep yellow, due to the degradation of the chlorophyll contents (Salvador *et al*., 2007). Besides colour and firmness, the quantification of starch conversion into sugar and fruit acidity can be used to evaluate the quality of bananas related to ripening stages (Li *et al*., 2009). Nevertheless, fruit acidity can be measured in terms of pH and titratable acidity (TA), which were used to describe the acidity of fruit vacuoles (Etienne *et al*., 2013).

The main objective of this study was to measure the physicochemical properties of *Musa Acuminata cv*. Berangan at different ripening stages by using few instrumental measurements under a normal storage condition without any inducement to fasten the ripening process. The changes of colour, firmness, total soluble solid content (TSS) and pH value were evaluated and the relationships between ripening stages and physicochemical properties were determined.

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Materials and Method

Samples

The uniform size of *Musa Acuminata cv*. Berangan at different ripening stages (1, 2 and 3) were bought from a wholesaler and stored at room temperature for at least 24 hours before the experiments. Fruits were visually inspected, and only those of regular shape and free from visual defects were selected. A total of 90 fruits were equally divided into 3 groups, representing ripening stages from 1 to 3.

Colour analysis

The peel colour properties were measured using colorimeter (Ultra-Scan Pro, Hunter Lab) by placing the fruit surface on a measuring head of 0.39 inches. The upper, middle and lower points of the surface area were randomly selected in order to get the mean of the measurements. Data were analyzed based on the CIELAB colour model which indicated by three axes i.e. L*, a*, and b*. The L* represents the degree of brightness or lightness which rated from 0 (black) to 100 (white). The a* shows the degree of redness with colour values ranging from –60 (green) to + 60 (red) while the b* shows the degree of yellowness when positive, and blueness when negative with a range from − 60 (blue) to + 60 (yellow).

Texture analysis

The determination of fruit firmness was done by using TA-XT Plus Texture Analyzer (Stable Micro System, Scarsdale, NY) which controlled by PC-based data acquisition. The value of maximum puncture force on each sample was measured by using 2mm cylindrical probe at return speed of 20mm/s.

Chemical analysis

A liquid sample of Berangan banana was taken from a blended solution of 30 grams of pulp tissue and 90ml of distilled water. The TSS was measured by expressing the brix percentage using refractometer (Digital ABBE Refractometer) while pH value was measured by pH meter (Mettler Toledo, SevenMulti)

Data analysis

Each instrumental measurement was done in three replications. Analysis of variance (ANOVA) was carried out to test the group mean value for each physicochemical property of bananas at different ripening stages. Multiple comparison test, using the Duncan post hoc procedure, was conducted to determine which group mean of the properties differed significantly. The collected data were analysed and plotted using the MS Excel software and SPSS (Version 22.0, Inc., Chicago, IL, USA).

Results and Discussion

Colour properties

Figure 1 shows the changes in colour properties (L*, a* and b*) for Berangan bananas in the early stage of ripening phase. The mean values of all colour properties are presented in Table 1. The L* and b* values increased between stages 1 and 2 before decreasing at stage 3. In contrast, a* values showed an inconsistent pattern of variation. A weak correlation was observed between each colour value and ripening stage (Table 2). These findings were incomparable as those obtained by Soltani *et al*. (2010) who found the good correlation between the colour difference meter measurement and ripening stage in Cavendish banana. This could be due to the variation of peel colour changes among bananas of different cultivar during the ripening process with respect to the degradation of chlorophyll pigments (Li *et al*., 1997). In addition, the effect of reproducibility of colorimeter component might affect the inconsistency of peel colour readings.

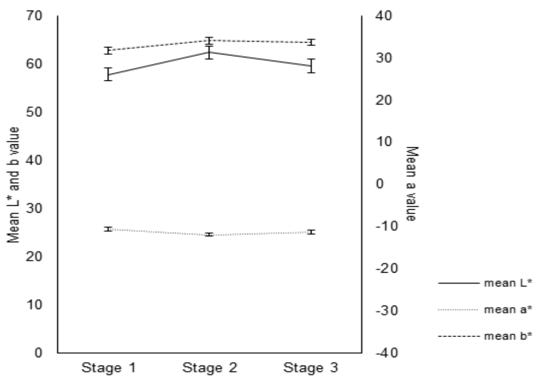

Figure 1. Colour properties for Berangan bananas at different ripening stages

Firmness

Variation of firmness values is illustrated in Figure 2, and the mean values of this parameter are tabulated in Table 1. The correlation between firmness and stage of banana ripeness is presented in Table 2 with the correlation coefficient (R) value being equal to 0.727. In the previous study, Salvador *et al*. (2007) suggested few textural properties that need to be considered besides the firmness such as puncture force, shear force, rupture force and elastic modulus, in order to have a better understanding of the changes in texture during ripening of banana. After all, the evaluation of the fruit softening is complex for fruit texture and depends on crop growing practices, ripening procedures and the different variety of banana cultivars (Charles and Tung, 1973).

Table 1 Mean values of physicochemical properties of bananas at different ripening stages

Ripening stage	L^*	a^*	b^*	Firmness (N)	PH	TSS (% Brix)
1	57.8013^{b}	-10.6090^{a}	31.7707^{b}	4.8738^{b}	6.8672^{a}	1.9333^{b}
2	62.3970^{a}	-11.9670^{c}	34.1167^{a}	5.7906^{a}	5.9313^{b}	1.4433^{c}
3	59.6050^{b}	-11.2840^{b}	33.7967^{a}	5.8632^{a}	5.7533^{b}	2.3800^{a}

[1]Means with the same letter are not significantly different ($P \leq 0.05$)

Table 2 Correlation matrix

	Ripening stage	Firmness	L^*	a^*	b^*	pH	TSS
Firmness	0.727						
L^*	0.243	0.2.999					
a^*	-0.348	-0.581	-0.35				
b^*	0.524	0.556	0.813	-0.474			
pH	-0.761	-0.763	-0.359	0.627	-0.639		
TSS	0.396	-0.109	-0.208	0.268	0.013	-0.036	

[1]The correlation was significant at the 0.01 level (2-tailed)

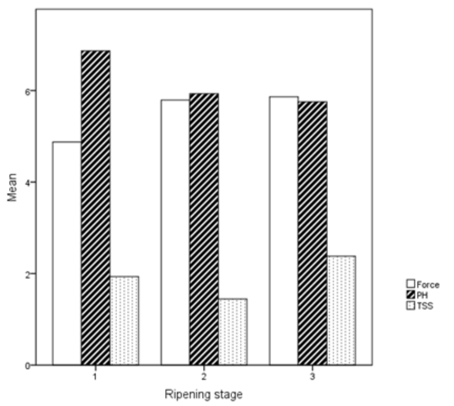

Figure 2. Firmness, pH value and TSS for Berangan bananas at different ripening stages

Total soluble solids content (TSS) and pH

Variations in pH and TSS values are also shown in Figure 2. There was a significant difference ($p<0.05$) in the mean values of TSS at the different ripening stages as shown in Table 1. The TSS decreased at stage 1 to stage 2 and then an increased was observed at stage 3. Meanwhile, the results indicated that the pH was decreased between stage 1 and stage 3. The correlation between chemical properties and stages of banana ripeness are presented in Table 2 with R values for pH and TSS were -0.761 and 0.396 respectively. These results are compatible with Soltani *et al.* (2010) who found a decrease in pH from stage 1 to stage 3 for Cavendish bananas. The changes in pulp acidity are mainly caused by the changes in malic acid, citric acid, oxalic acid and potassium during post-harvest ripening of banana fruits (Etienne *et al*., 2013). In addition, an increase in TSS can be used as an indicator to relate the conversion of starch into soluble sugar for banana (Ahmad *et al*., 2001; Soltani *et al*., 2011; Tapre and Jain, 2012).

Conclusion

The changes in physicochemical properties of *Musa Acuminata cv*. Berangan bananas at early ripening stages were studied. Results showed the significant differences in colour, firmness, pH and TSS subjected to the different stage of ripeness. However, it is important to select quality related attributes that best define the actual ripening stages to perform better classification in the production of banana. The producers, distributors and handlers, must be able to meet consumer demand with support from researchers, by developing an advance post-harvest technologies that translate the related sensory attributes of specific physicochemical properties of the fruits. In conclusion, these fundamental findings could point towards the new approach in automatic monitoring and predicting the quality of different varieties of banana.

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