Some changes in physiological and biochemical properties of *Musa paradisiaca* and *Musa acuminata* AA banana peel during ripening harvested in Tien Giang Province, Vietnam

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ABSTRACT

The objective of this study was to determine some physiological properties (mass ratio, moisture) and biochemical properties (the content of the chlorophyll, carotenoids and The Total Polyphenol (TPC)) of *Musa paradisiaca* and *Musa acuminata* AA banana varieties peel, which were harvested in Tien Giang province, Vietnam at 03 stages of ripeness (I, III and VI in the color index 08 ripeness of banana). The results showed that the ripening from I to VI maturity had a significant effect on the mass ratio, the moisture, the chlorophyll, the carotenoids, and the TPC in 02 banana varieties peel and followed different trends. The mass ratio and the moisture decreased, the chlorophyll and the carotenoids content recorded as opposite trends with degradation of chlorophyll and synthesis of carotenoids occurred simultaneously, the most special, the TPC increased and reached to a maximum value at III maturity and decreased after. Results suggest that two banana varieties of peel could be effectively used for the extraction of polyphenol compounds in the future.

1. Introduction

Banana is a rich in nutrients and popular fruit on over the world. They were planted in many tropical countries and sub-tropical regions. The banana pulp contains sugar, healthy starch, fiber, vitamins, and minerals, etc. Some typical vitamins and minerals that could be mentioned in banana pulp included vitamin B6, vitamin C, vitamin A, potassium, iron, folate, etc. They have affected supporting the treatment of muscle cramps, stimulating the production of hemoglobin to improve health for low blood pressure and anemia patients (Bukhru, 1995). In Vietnam, the banana pulp is not only a useful part. According to Vietnamese traditional medicine, banana peel is quite an acrid taste and has been used as medicine. They have effective in treating some diseases such as stomach ulcers, abdominal pain, diarrhea, dysentery, high blood pressure, deworming, etc. Recently, there are many domestic and foreign researchers have reported that banana peel contained a lot of bioactive compounds.

Which, polyphenol compounds and pigments are the most popular bioactive compounds as tannins (Tingru, Hongling, Shiwen, & Dandan, 2014), terpenoids (Ali, 1992), cyclomusalenon (Do, Tran, & Pham, 2006), chlorophyll, and carotenoids (Moreno et al., 2020).

According to Le (2003), bioactive compounds are found in many plants such as

vegetables, fruits, and flowers. They are not only physiological functions for plants, but also they have many active effects on human and animals health due to well antioxidant, anti-inflammatory, antibacterial, and anti-allergic. They are recorded that capable of preventing dangerous diseases such as cancer, neurodegenerative disorders or diseases, diabetes, arthritis, heart disease (Jin & Russell, 2010; Uddin, Akond, Mubassara, & Yesmin, 2008). In fruits, the content of bioactive compounds is a difference between varieties and stages of ripeness (Lai, Tran, & Pham, 2018; Pham, Truong, Nguyen, & Tran, 2019). So, researching the physiological and biochemical changes in banana peels is necessary for determining the most suitable maturity to extract bioactive compounds from this material.

2. Materials and methods

2.1. Materials

2.1.1. Samples preparation

Three bunches for each banana variety were harvested in gardens in Chau Thanh District, Tien Giang Province, Vietnam. After that, they were transported to the laboratory and ripened naturally. Based on the color scale of banana peel ripeness as described by Thompson, Supapvanich, and Sirison (2019), the healthy banana fruits at the 03 stage of ripeness (I, III, and VI) (Figure 1) were washed in tap water to remove physical impurities such as soil particles, floral remains, the latex. Then, they were peeled. The peeled bananas were cut into 0.3 - 0.5cm pieces and dried at 50 - 55℃ by drying equipment (Yamato DK412C, Japan). After drying, the banana peels with a moisture content of 6.64% were finely ground into powder crushed by a dry mill to a size of ≤ 1.40mm. The banana peels powder of 02 varieties was collected and stored separately in PA zip bags at -20℃ until using (Rebello, Asok, Mundayoor, & Jisha, 2014).

Figure 1. *M. paradisiaca* (1) and *M. acuminata* AA (2) during ripening
I maturity (A), III maturity (B), VI maturity (C)

2.1.2. Chemicals

Folin-Ciocalteu reagents, gallic acid (Merck, Germany); absolute ethanol (Cemaco, Vietnam), Na_2CO_3 (China).

2.2. Methods

2.2.1. Determination of the mass ratio and moisture content of banana peels

The mass ratio (%) of banana peels was determined to base on the ratio of the weight of

the peel sample per the total weight of the fruit. The moisture content (%) in banana peels was determined base on the difference in the weight of the peel sample before and after heating at 105℃ to constant weight. The data reported here are the average of three replicated experiments.

2.2.2. Preparation of analysis extract

Dried banana peel powder was weighed 0.5g and poured into test tubes type 50mL. Then, 25mL of 70% ethanol was added to each test tube, shaken and kept them at room temperature for 30min. Continue, they were put into a thermostatic bath at 55°C and waited for 30min. After 30min, the test tubes were put into ice to stop extraction. Then, mixtures were centrifuged at 5,500rpm at 4℃ for 15min to collect the extract. Finally, the extract was poured into a volumetric flask type 50mL and added solvent to the same volume of 50mL; this helps calculation later easily.

2.2.3. Determination of the chlorophyll and the carotenoids content

The chlorophyll and the carotenoids contents were determined based on the description by D. T. Nguyen (2019) with some modifications: the extract of the banana peels powder was measured for absorbance (OD) at 480, 645, and 663nm, respectively with the blank was like 70% ethanol by using Cary 50 UV-Visible spectrophotometer. The content of two pigments were calculated to follow the formula as:

$$C_{Chlorophyll} = [(20.2 \times OD_{645} - 8.02 \times OD_{663})/m \times (1 - w)] \times V \times K \quad (1)$$

$$C_{Carotenoids} = [(OD_{480} + 0.114 \times OD_{663} - 0.638 \times OD_{645})/m \times (1 - w)] \times V \times K \quad (2)$$

In which: $C_{Chlorophyll}$ and $C_{Carotenoids}$ are the content of chlorophyll and the carotenoids, respectively (µg/g DM); OD_{480}, OD_{645}, OD_{663} are absorbance value of extract at 480, 645, and 663nm, respectively; V is volume of extract (mL); m is weight of banana peel powder (g); w is moisture of banana peel powder; K is level of dilution.

2.2.4. Determination of the Total Polyphenols Content (TPC)

The Total Polyphenols Content (TPC) (mg gallic acid (GAE) per g Dry Material (DM)) was determined by the Folin-Ciocalteau method based on the description by Yadav and Agarwala (2011): 01mL gallic acid solutions of 0, 20, 40, 60, 80, and 100µg/mL concentrations were mixed with 2.5mL of 10% Folin-Ciocalteu reagent into test tubes, waited for 05min and continue added 02mL 2% Na_2CO_3 solution. Mixtures were shaken and kept in the dark at room temperature for 60min. After 60min, the mixtures absorbance (OD) values were determined at 765nm. The OD values were recorded and draw a linear ($y = 0.0118x - 0.0095$; $R^2 = 0.9979$). The extracts were performed similarly with standard polyphenol; the TPC in the extract was determined following the formula:

$$TPC = \frac{a \; x \; V \; x \; K}{1000 \; x \; m \; x \; (1-w)} \quad (3)$$

In which: TPC is the total polyphenols content (mgGAE/g DM); a is x value from the linear equation with gallic acid (µgGAE/g DM); V is a volume of extract (mL); K is level of dilution; m is the weight of banana peels powder (g); w is moisture content of banana peels powder.

2.2.5. Methods of analysis and data processing

All data of this study were processed using Microsoft Excel, Minitab 16 Statistical Software to analyze statistics and ANOVA.

3. Results and discussion

3.1. The mass ratio and moisture content changes in 02 banana varieties peels during ripening

The results about the changes in the mass ratio and the moisture of 02 banana varieties peel at 03 maturity stages are shown in Figure 2 and Table 1.

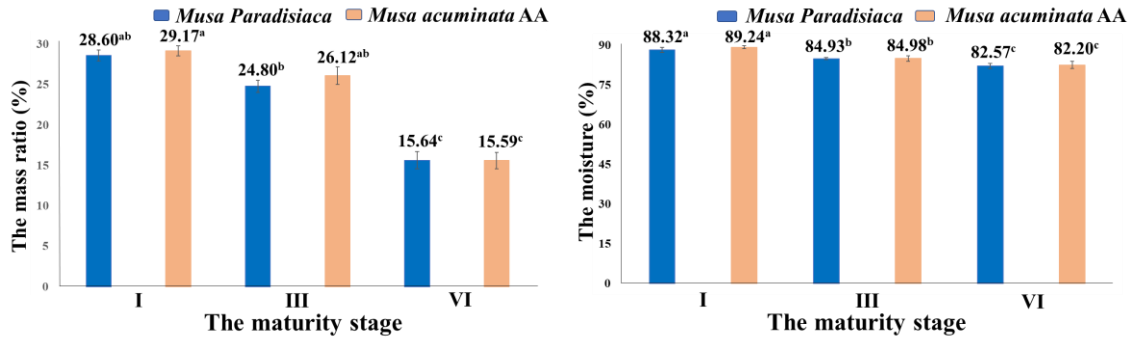

Figure 2. The mass ratio and the moisture content of 02 banana varieties peel during ripening

Table 1

The mean values of the mass ratio and the moisture of banana varieties

Maturity	Banana varieties	The mass ratio (%)	The moisture (%)
Mean of maturity	I	28.95[a]	88.78[a]
	III	25.46[b]	84.96[b]
	VI	15.62[c]	82.38[c]
Level of significance		*	*
Mean of banana variety	*M. paradisiaca*	23.01[ab]	85.15[ab]
	M. acuminata AA	23.63[a]	85.60[a]
Level of significance		non	non

Note: "non" means that the difference is not statistically significant, "" means that the difference is statistically significant at the 5% level of significance by Tukey test
Source: Data analysis result of the research

The results in Figure 2 showed that the ripeness has affected the mass ratio and the moisture content of *M. paradisiaca* and *M. acuminata* AA varieties peels with the following reduction trend during ripening. The percentage reduction of the mass ratio and the moisture content was 13.58% and 6.67%, respectively. The banana peel at VI maturity had the lowest mass ratio, and the moisture and difference were significant at the 5% level of significance compared with the other 02 maturities. The results in Table 1 showed that two these physiological indicators of all 02 banana varieties peel were only dependent on the maturity.

The mass ratio mean of the peel of 02 banana varieties in this study was 23.63% and 23.01%, respectively. This banana peel by-products would be a big and potential source for extraction of biological compounds, pectin, or production of organic fertilizers and bioplastics. However, the above results also showed that the moisture of banana peel was high, with values being higher than 80%. The moisture at a high level together with activities of enzymes in during ripening strongly, so the banana peel would be decomposed quickly. Therefore, banana peel

material needs to be dried to preserve and help the condition for extraction of biological compounds easily.

The reduction trend in the mass ratio and the moisture content of banana peel during ripening of this study were also recorded in some other studies before. In a study by Lai et al. (2018), from I to V maturity, the mass ratio of *Musa babisiana* peel decreased 14.73%. In another study, the moisture of *Musa paradisiaca* peel decreased 8.93% during ripening (Pham et al., 2019).

3.2. The changes in total polyphenol, chlorophyll, and total carotenoid content in the peel of 02 banana varieties during ripening

The total chlorophyll, the total carotenoids, and the total polyphenol content in peel of 02 banana varieties at 03 stages of ripeness were shown in Table 2.

Table 2

The content of the total polyphenol, Chlorophyll, and Carotenoids of bananas peel during ripening

Maturity	Banana varieties	Total Chlorophyll (µg/g DM)	Total carotenoid (µg/g DM)	Total polyphenol (mgGAE/g DM)
I	*M. paradisiaca*	678.20 ± 53.80^{a}	47.33 ± 2.20^{b}	8.97 ± 0.70^{c}
	M. acuminata AA	500.50 ± 32.30^{b}	38.39 ± 2.17^{c}	12.38 ± 1.39^{b}
III	*M. paradisiaca*	266.97 ± 16.01^{c}	49.72 ± 2.67^{b}	13.24 ± 0.45^{b}
	M. acuminata AA	329.10 ± 27.40^{c}	40.55 ± 2.32^{c}	16.54 ± 0.80^{a}
VI	*M. paradisiaca*	68.65 ± 2.84^{d}	59.18 ± 2.91^{a}	5.69 ± 1.00^{d}
	M. acuminata AA	103.10 ± 19.50^{d}	43.25 ± 2.12^{bc}	9.63 ± 0.33^{c}
Mean of maturity	I	589.33^{a}	42.86^{bc}	10.67^{b}
	III	298.53^{b}	45.13^{b}	14.89^{a}
	VI	85.85^{c}	51.22^{a}	7.66^{c}
Level of significance		*	*	*
Mean of banana variety	*M. paradisiaca*	337.94^{a}	52.08^{a}	9.30^{b}
	M. acuminata AA	310.86^{ab}	40.73^{b}	12.84^{a}
Level of significance		non	*	*

Note: "non" means that the difference is not statistically significant, "" means that the difference is statistically significant at the 5% level of significance by Tukey test
Source: Data analysis result of the research

3.2.1. The chlorophyll and the carotenoids content changes

The results in Table 2 showed that the chlorophyll and the carotenoids content in all 02 banana varieties peel changes during ripening follow opposite trends. The chlorophyll content in the peel of *M. paradisiaca* variety was higher than *M. acuminata* AA variety at I maturity with 678.20 and 500.50 (µg/g DM), respectively. During ripening from the I to VI maturity stage, the chlorophyll content was degraded 609.55 and 397.41 (µg/g DM) equivalent to 89.88% and 79.41%, respectively. At the same time, the carotenoids content was synthesized in all 02 banana

varieties peel with different levels. During ripening, the carotenoids content increased *M. paradisiaca* and *M. acuminata* AA varieties with 11.85 and 4.86 (µg/g DM) equivalent 25.04% and 11.24%, respectively. Besides that, the carotenoids content was dependent on both the maturity stage and the banana variety, but the chlorophyll content was only dependent on the maturity stage.

During ripening, the content of pigments in the fruit peel changed. This caused the peel color change of them and also one of the signs to determine the maturity stages of fruits. These change trends are decomposition of chlorophyll (green pigment) quickly due to the activity of chlorophyllase and the self-oxidation under the influence of oxygen and sunlight. At the same time, the biosynthesis of carotenoids from yellowish green to full-yellow stages took place and increased the carotenoids content including xantophylls and carotenes. So that, the banana peel is more and more bright, the green color is fading, more yellow, and turns full yellow when ripe (Jain, Dhawan, Malhotra, & Singh, 2003). The changes of pigments content are very different in each fruit, so the colors of the peels are also different.

The results in Table 2 showed that there was a difference in the TPC of 02 banana varieties peel during the ripening. They increased from I to III maturity and decreased from III to VI maturity. The TPC in the peel of M. paradisiaca variety is always lower than the *M. acuminata* AA variety at all 03 maturity stages. They both reached the highest value at III maturity with 13.24 and 16.54 (mgGAE/g DM), respectively. Besides that, the carotenoids content was dependent on both the maturity stage and the banana variety, but the chlorophyll content was only dependent on the maturity stage. Some studies before recorded that the main constituent of polyphenol compounds in banana peel was tannins (Moreno et al., 2020; Tingru et al., 2014).

3.2.2. The Total Polyphenols Content (TPC) changes

The TPC increasing trend of 02 banana varieties peel at the beginning process and decreasing after that was also recorded on *M. paradisiaca* variety peel. According to Pham et al. (2019) their TPC increased sharply from I to III maturity with 1.55 (mgGAE/g DM) equivalent 02 to 03 times with the remaining maturity stages and decreased after that. However, according to Lai et al. (2018), the TPC in *M. babisiana* peel decreased 2.55 times in the ripening process from I to V maturity. According to Goldstein and Swain (1963), the increase in the polymerization of leucoanthocyanidins during ripening is the cause of TPC decreasing trends, and this is different among fruits.

The TPC of 02 banana varieties peel at III maturity in this study were 13.24 and 16.54 (mgGAE/g DM); they were higher than cacao pod husk with 7.23 (mgGAE/g DM) (T. V. Nguyen et al., 2020) or apple peel with 13.10 (mgGAE/g DM) (Orozc, Coba, & Velázquez, 2009). But they were lower than *M. babisiana* with 20.02 (mgGAE/g DM) (Lai et al., 2018) with 79.43 (mgGAE/g DM) or *Anona squamosal* peel (D. D. Nguyen & Vu, 2019).

4. Conclusion

The results showed that there were differences in the mass ratio, the moisture, the chlorophyll, the carotenoids, and the TPC in the peel of two banana varieties as *M. paradisiaca* and *M. acuminata* AA during ripening with the following difference trends. Specific, the mass ratio, the moisture, and the chlorophyll content decreased; the carotenoids and the TPC contents increased at the beginning of the ripening process and decreased after that. Therefore, the banana peels at III maturity can serve as a potential biomaterial in the future.

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