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Properties of Indonesian plantain cultivars during ripening and recommendation for flour ingredients

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Abstract: This research aims to examine the physicochemical changes in five Indonesian cultivars of plantain during the normal ripening and determine the optimal ripeness stage for flour. Cultivars 'Kapas', 'Tanduk', 'Raja Bulu', 'Siam', and 'Kepok Kuning' were selected for the research. The cultivars were stored at room temperature of 24.8–31.7 °C and relative humidity of 59.5%–99.9%. Peel colour, weight loss, pulp to peel ratio, firmness, pH, TSS, moisture content, starch, reducing sugars, and titratable acidity were evaluated. The results showed that the best unripe flour based on the starch content for 'Kapas', 'Raja Bulu', 'Tanduk', and 'Siam' cultivars was at stages 1–3 and 'Kepok Kuning' cultivar at ripening stages 1–2. On the other hand, in ripe banana flour, the best stage for 'Kepok Kuning', 'Tanduk', and 'Siam' cultivars was stage 4, for 'Raja Bulu' cultivar stages 4–5 and for 'Kapas' cultivar stages 4–7.

Keywords: flour; plantain; physicochemical properties; ripening stage

Bananas as climacteric fruits undergo physical changes (peel colour, texture, flavour, and taste) and chemical changes (moisture content, starch, sugar, and acidity) during the ripening process. Based on peel colour changes, the banana consists of 7 ripening stages (Sogo-Temi et al. 2014). The banana ripening process includes physiological changes such as peel colour from green to yellow, starch degradation, increased sugar content, increased flavour components, and texture changes (Özdemir 2016). The ripening stage after harvesting is an essential factor in determining its suitability for product processing and development.

Bananas that can be used as raw materials for making good flour have to meet a requirement for a starch content of 16.5% to 19.5% (Harefa and Pato 2017). The plantain has a higher starch content than dessert bananas, ranging from 20% to 30%. It is better to choose plantain bananas for the manufacturing of flour, either raw or ripe.

Based on previous research, there is an effect of ripening stages on the flour produced (Soltani et al. 2010; Yap et al. 2017; Mohapatra et al. 2016). So far, no specific research has been found to examine physicochemical changes of several plantain cultivars used as raw materials for flour. The physicochemical changes

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of the five Indonesian plantain cultivars will be assessed for each level of ripening stage. It will be recommended which level of ripening stage is appropriate for the type of flour to produce.

MATERIAL AND METHODS

Fruit materials and sample preparation. Fresh cut plantains were collected from Sumedang Regency, West Java. A botanist identified the five cultivars of plantain used in this research 'Herbarium Bogoriense performed botanical authentication', Research Center for Biology, Indonesian Institute of Sciences (No. 1110/IPH.1.01/If.07/V/2019; No.1730/ IPH.1.01/If.07/IX/2019).

The experiment was carried out in ripening sacks with fruits kept at a humidity level of 59.5–99.9% and room temperature of 24.8–31.7 °C. The fruit-filled sacks were placed on a pallet (10 cm above the floor) for 12 days. Observations were made every day to observe the change of plantains during the natural ripening process.

Analysis of physicochemical properties. The analysis of physicochemical properties of banana samples included peel colour (observed visually), weight loss and pulp to peel ratio (Mohapatra et al. 2016); the firmness level of the whole plantain was measured using a penetrometer; the pH value of the pulp was obtained using a pH meter (Lab 855-Meter; Merck: SI Analytics; Germany); total soluble solids of the pulp (TSS) were determined using a refractometer (Alberto Bertuzzi SpA; Italy) (Bertuzzi; Bertuzzi Strumenti Scienti®ci SpA, Italy); moisture content and titratable acidity of pulp (AOAC 2004); and starch content and reducing sugars (Sudarmadji 2003).

Statistical analysis. The experiment used a randomized factorial design with two factors, plantain cultivars (5 levels) and ripening stages (7 levels), and each treatment was repeated three times. The five cultivars of plantain used in this research were V_1 = *M. acuminata* × *M. balbisiana* (AAB) cv. 'Kapas', V_2 = *M. acuminata* × *M. balbisiana* (AAB) cv. 'Raja Bulu', V_3 = *M. acuminata* × *M. balbisiana* (ABB) cv. 'Kepok Kuning', V_4 = *M. acuminata* × *M. balbisiana* (AAB) cv. 'Tanduk', and V_5 = *M. acuminata* × *M. balbisiana* (ABB) cv. 'Siam'. Seven ripening stages were S_1 = stage 1 (fully unripe), S_2 = stage 2 (unripe), S_3 = stage 3 (early ripe), S_4 = stage 4 (partially ripe), S_5 = stage 5 (ripe), S_6 = stage 6 (fully ripe), S_7 = stage 7 (overripe). All experimental data were analysed statistically for normality and presented as mean ± standard error − the differences between treatments were based on variance (α = 5%). Significant differences between mean values were determined using Duncan's Multiple Range Test (α = 5%).

RESULTS AND DISCUSSION

Physical properties. The five plantain cultivars changed the colour from the beginning to the end of storage (Figure 1). Discoloration of the banana peel during the ripening process (loss of greenness and reddish and yellowish colour) is caused by chlorophyll degradation (Salvador et al. 2007). During the ripening process, carotenoid pigments are rising, which causes the amount of chlorophyll to decrease to zero in ripe fruit (Yang et al. 2009). The primary carotenoid pigments that appear in yellow (ripe) bananas are α-carotene, β-carotene, and lutein called carotene as well (Aquino et al. 2018).

In this study, the average weight loss of five plantain cultivars increased from 8.27% to 20.30% (Table 1). The cultivar that produced the highest weight loss was 'Tanduk' cultivar (20.30%), while the cultivar that produced the lowest weight loss was 'Kepok Kuning' cultivar (8.27%). The percentage of banana weight loss increases continuously during the ripening process (Arista et al. 2017). Transpiration becomes the leading cause of water loss, which causes weight loss in the fruit (Sukasih and Setyadjit 2018).

The pulp to peel ratio in the 'Kapas' cultivar was 1.11 in stage 1 and increased to 1.60 in stage 7. Meanwhile, in the 'Tanduk' cultivar, the pulp to peel ratio was 2.23 in stage 1 and increased to 4.53 in stage 7 (Table 1). It was comparable with Ayo-Omogie et al. (2010), who stated that the pulp to peel ratio in 'Cardaba' bananas increased gradually by 1.40–2.03 until the banana reached stage 7, which is caused by decreased fruit peel weight and increased fruit flesh weight. Reduction in peel weight and weight gain of fruit flesh occur due to the migration of moisture content from fruit peel into fruit flesh (Sen 2012).

The 'Siam' cultivar firmness level was 0.11 mm g^{-1} s^{-1} in stage 1 and it increased to 3.64 mm g^{-1} s^{-1} in stage 7. Meanwhile, the 'Kapas' cultivar firmness level was 0.29 mm g^{-1} s^{-1} in stage 1 and it increased to 1.69 mm g^{-1} s^{-1} in stage 7. This cultivar had the lowest increase in the firmness level (1.40 mm g^{-1} s^{-1}). During the ripening process, there was a decrease in cellulose and hemicellulose in the plantain fruit peel, which causes the peel to become softer (Emaga et al. 2008). The firmness level of five plantain cultivars in this study began to increase significantly ($P < 0.05$) in stages 5–7 (Table 1). In stages 5 to 7, cellulose content decreased due to partial cellulose degradation to monosaccharides during the ripening process (Emaga et al. 2008). The degradation of pectin causes an increase in osmotic

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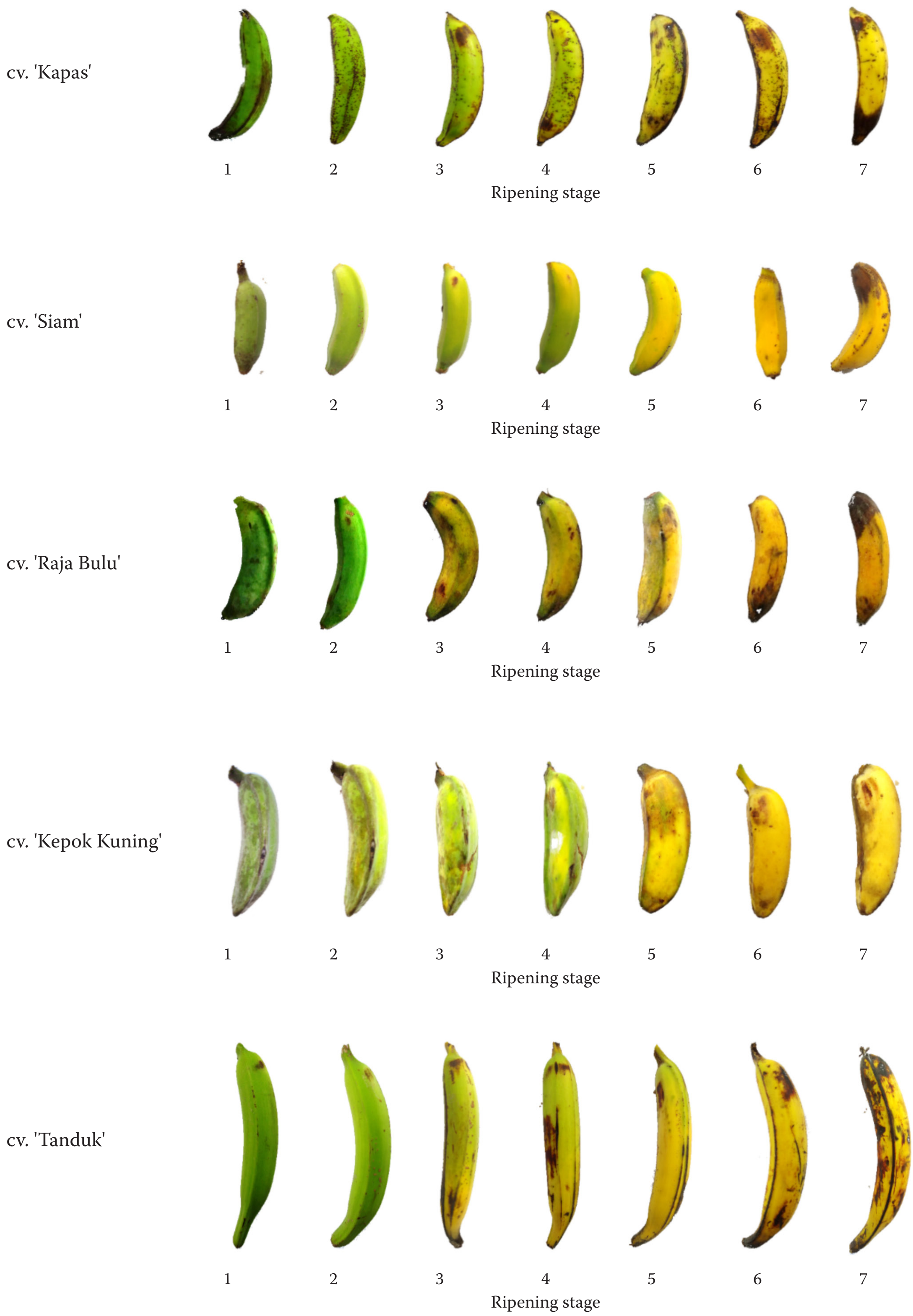

Figure 1. Peel colour changes of several Indonesian plantain cultivars [*Musa acuminata* × *Musa balbisiana* (AAB)] during ripening

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Table 1. The physical content of several Indonesian plantain cultivars during ripening

Response	Stage of ripening						
	stage 1	stage 2	stage 3	stage 4	stage 5	stage 6	stage 7
Weight loss (%)							
Kapas	0.00 ± 0.00^{Ca}	2.73 ± 1.15^{Cb}	6.15 ± 2.57^{Cc}	8.21 ± 2.78^{Cd}	11.24 ± 1.62^{Ce}	$13.13 \pm 0,21^{Cf}$	14.79 ± 1.52^{Cg}
Raja Bulu	0.00 ± 0.00^{Ca}	4.73 ± 2.48^{Cb}	6.28 ± 1.06^{Cc}	8.37 ± 0.40^{Cd}	10.51 ± 0.42^{Ce}	13.68 ± 1.29^{Cf}	15.55 ± 0.94^{Cg}
Kepok Kuning	0.00 ± 0.00^{Aa}	1.02 ± 0.09^{Ab}	1.74 ± 0.21^{Ac}	2.73 ± 0.72^{Ad}	3.46 ± 0.84^{Ae}	6.05 ± 1.39^{Af}	8.27 ± 0.92^{Ag}
Tanduk	0.00 ± 0.00^{Da}	4.47 ± 0.35^{Db}	8.03 ± 0.55^{Dc}	12.28 ± 0.24^{Dd}	14.83 ± 0.99^{De}	17.45 ± 2.32^{Df}	20.30 ± 3.97^{Dg}
Siam	0.00 ± 0.00^{Ba}	1.37 ± 0.03^{Bb}	2.73 ± 0.92^{Bc}	4.79 ± 0.88^{Bd}	6.16 ± 0.85^{Be}	6.84 ± 0.83^{Bf}	8.91 ± 0.18^{Bg}
Pulp-to-peel ratio							
Kapas	1.11 ± 0.08^{Aab}	1.22 ± 0.08^{Aa}	1.36 ± 0.15^{Aa}	1.48 ± 0.19^{Aa}	1.55 ± 0.06^{Aab}	1.59 ± 0.17^{Aab}	1.60 ± 0.01^{Ab}
Raja Bulu	0.80 ± 0.09^{Aab}	0.85 ± 0.11^{Aa}	1.01 ± 0.04^{Aa}	1.15 ± 0.12^{Aa}	1.19 ± 0.04^{Aab}	1.36 ± 0.01^{Aab}	1.72 ± 0.21^{Ab}
Kepok Kuning	1.01 ± 0.11^{Aab}	1.09 ± 0.16^{Aa}	1.16 ± 0.04^{Aa}	1.20 ± 0.01^{Aa}	1.25 ± 0.02^{Aab}	1.64 ± 0.19^{Aab}	$1.680.44^{Ab}$
Tanduk	2.23 ± 0.01^{Bab}	2.41 ± 0.07^{Ba}	2.74 ± 0.02^{Ba}	2.83 ± 0.47^{Ba}	3.13 ± 0.36^{Bab}	3.78 ± 0.004^{Bab}	4.53 ± 0.005^{Bb}
Siam	2.02 ± 0.03^{Bab}	2.39 ± 0.86^{Ba}	2.64 ± 0.91^{Ba}	2.98 ± 0.61^{Ba}	3.27 ± 1.09^{Bab}	3.54 ± 0.32^{Bab}	3.33 ± 0.01^{Bb}
Firmness level (mm g^{-1} s^{-1})							
Kapas	0.29 ± 0.01^{Abcd}	0.38 ± 0.03^{Aa}	0.60 ± 0.11^{Aab}	1.09 ± 0.014^{Ab}	1.30 ± 0.08^{Acd}	1.50 ± 0.11^{Ade}	1.69 ± 0.01^{Ae}
Raja Bulu	0.16 ± 0.00^{Abcd}	0.35 ± 0.01^{Aa}	0.62 ± 0.11^{Aab}	0.83 ± 0.01^{Ab}	1.25 ± 0.18^{Acd}	1.35 ± 0.01^{Ade}	2.14 ± 0.25^{Ae}
Kepok Kuning	0.17 ± 0.04^{ABbcd}	0.78 ± 0.03^{ABa}	1.25 ± 0.07^{ABab}	1.33 ± 0.30^{ABb}	1.66 ± 0.00^{ABcd}	2.26 ± 0.08^{ABde}	2.41 ± 0.58^{ABe}
Tanduk	0.34 ± 0.00^{ABbcd}	0.46 ± 0.06^{ABa}	0.91 ± 0.04^{ABab}	1.63 ± 0.04^{ABb}	1.70 ± 0.05^{ABcd}	2.37 ± 0.04^{ABde}	2.94 ± 0.06^{ABe}
Siam	0.11 ± 0.01^{Bbcd}	0.76 ± 0.00^{Ba}	1.19 ± 0.04^{Bab}	1.82 ± 0.06^{Bb}	2.20 ± 0.00^{Bcd}	3.25 ± 0.07^{Bde}	3.64 ± 0.03^{Be}

Mean value with a different letter in the same row (uppercase) and the same column (lowercase) was significantly different (Duncan $P < 0.05$)

pressure on banana flesh, resulting in a decrease in turgor pressure and finally resulting in softening of the fruit texture (Yap et al. 2017).

The five cultivars showed pH values ranging between 1.14 and 1.59, which had a similar tendency to decrease (Table 2). The two cultivars with the highest pH value (both 1.59) were 'Kepok Kuning' cultivar and 'Siam' cultivar. The decrease in pH value during the ripening process is in line with the research results by Zulkifli et al. (2016) on banana 'Berangan' cultivar. There is a process of accumulation of acid content during ripening such as malic and citric acid in bananas (Rosalina et al. 2018). The increasing value of acid levels in fruit can cause a decrease in the pH value of bananas (Kulkarni et al. 2011).

Chemical properties. Five cultivars had an average increase in total titratable acidity levels ranging from 0.55% to 1.20% (Table 2). An increase in the value of titrated acid levels can be caused by conversion of simple sugars into organic acids (Soltani et al. 2010). The value of total titratable acidity levels in this research was higher than the total acids of 'red' banana from Mohapatra et al. (2016) research. This difference is due to different cultivars. The results of this study are consistent with the titratable acidity of 'red' banana (Mohapatra et al. 2016) and 'Leb Mue Nang' banana (Youryon and Supapvanich 2017).

Moisture content began to gradually increase in stage 2, and the highest increase occurred in stage 4, then it increased slightly (Table 2). This process occurs when water is transferred from the peel to the flesh and water is lost out of the fruit, namely due to respiration and osmotic changes (Arista et al. 2017). The breakdown of starch during the metabolic process can also cause the moisture content of the material to increase. The amount of moisture content of bananas that increases during ripening correlates with an increase in total soluble solids because starch is hydrolyzed into sugar (Mohapatra et al. 2016) and transfers water from the peel to the flesh (Arista et al. 2017).

The 'Raja Bulu' cultivar had the highest starch reduction level (27.24%). 'Raja Bulu' cultivar had a starch content of 35.03% in stage 1 and it decreased to 7.79% in stage 7. The 'Kapas' cultivar (16.03%) had the lowest relatively stable starch reduction level. This cultivar had a starch content of 34.32% in stage 1 and

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Table 2. The chemical content of several Indonesian plantain cultivars during ripening

Response	Stage of ripening						
	stage 1	stage 2	stage 3	stage 4	stage 5	stage 6	stage 7
pH Value							
Kapas	5.95 ± 0.004^{Acd}	5.86 ± 0.24^{Ae}	5.36 ± 0.07^{Ade}	4.90 ± 0.01^{Abc}	4.80 ± 0.001^{Aabc}	4.76 ± 0.01^{Aab}	4.56 ± 0.47^{Aa}
Raja Bulu	5.99 ± 0.04^{Acd}	5.63 ± 0.54^{Ae}	5.46 ± 0.70^{Ade}	4.92 ± 0.01^{Abc}	4.91 ± 0.00^{Aabc}	4.86 ± 0.05^{Aab}	4.85 ± 0.03^{Aa}
Kepok kuning	6.26 ± 0.18^{Acd}	5.47 ± 0.30^{Ae}	5.18 ± 0.01^{Ade}	5.36 ± 0.06^{Abc}	5.11 ± 0.15^{Aabc}	4.71 ± 0.04^{Aab}	4.67 ± 0.03^{Aa}
Tanduk	6.13 ± 0.03^{Acd}	5.98 ± 0.09^{Ae}	5.48 ± 0.17^{Ade}	4.86 ± 0.01^{Abc}	4.71 ± 0.00^{Aabc}	4.63 ± 0.00^{Aab}	4.62 ± 0.02^{Aa}
Siam	6.18 ± 0.01^{Acd}	5.89 ± 0.00^{Ae}	5.75 ± 0.01^{Ade}	5.50 ± 0.08^{Abc}	5.21 ± 0.01^{Aabc}	5.01 ± 0.01^{Aab}	4.59 ± 0.03^{Aa}
Total titratable acidity (%)							
Kapas	0.44 ± 0.02^{Abc}	0.35 ± 0.01^{Aa}	0.64 ± 0.01^{Aab}	0.65 ± 0.32^{Abc}	0.91 ± 0.08^{Acd}	0.93 ± 0.11^{Acd}	1.00 ± 0.04^{Ad}
Raja Bulu	0.24 ± 0.17^{Abc}	0.08 ± 0.00^{Aa}	0.69 ± 0.10^{Aab}	0.82 ± 0.05^{Abc}	0.93 ± 0.23^{Acd}	0.96 ± 0.21^{Acd}	1.3 ± 0.250^{Ad}
Kepok kuning	0.05 ± 0.00^{Abc}	0.41 ± 0.10^{Aa}	0.38 ± 0.13^{Aab}	0.43 ± 0.01^{Abc}	0.53 ± 0.01^{Acd}	0.66 ± 0.03^{Acd}	0.74 ± 0.09^{Ad}
Tanduk	0.18 ± 0.02^{Abc}	0.20 ± 0.01^{Aa}	0.34 ± 0.04^{Aab}	0.67 ± 0.11^{Abc}	0.87 ± 0.01^{Acd}	1.20 ± 0.07^{Acd}	1.27 ± 0.04^{Ad}
Siam	0.09 ± 0.02^{Abc}	0.16 ± 0.03^{Aa}	0.40 ± 0.01^{Aab}	0.72 ± 0.03^{Abc}	0.84 ± 0.13^{Acd}	1.11 ± 0.01^{Acd}	1.29 ± 0.11^{Ad}
Moisture content (%)							
Kapas	58.26 ± 1.33^{Ab}	58.73 ± 0.75^{Aa}	58.14 ± 1.87^{Ab}	59.61 ± 0.69^{Ab}	59.54 ± 1.25^{Ab}	60.58 ± 0.96^{Ab}	60.65 ± 0.42^{Ab}
Raja Bulu	59.44 ± 2.38^{ABb}	59.86 ± 1.19^{ABa}	60.39 ± 2.31^{ABb}	61.71 ± 2.74^{ABb}	61.79 ± 0.94^{ABb}	62.75 ± 0.03^{ABb}	64.90 ± 3.02^{ABb}
Kepok kuning	59.38 ± 3.28^{ABb}	60.10 ± 4.31^{ABa}	60.90 ± 1.47^{ABb}	60.64 ± 3.53^{ABb}	60.93 ± 1.66^{ABb}	61.72 ± 0.13^{ABb}	62.68 ± 0.21^{ABb}
Tanduk	60.01 ± 2.34^{Bb}	61.40 ± 0.36^{Ba}	61.87 ± 0.54^{Bb}	62.31 ± 0.41^{Bb}	62.87 ± 0.13^{Bb}	62.87 ± 2.43^{Bb}	63.56 ± 0.33^{Bb}
Siam	52.54 ± 1.57^{ABb}	58.42 ± 2.80^{ABa}	60.85 ± 0.23^{ABb}	62.08 ± 1.80^{ABb}	63.34 ± 2.61^{ABb}	64.71 ± 0.03^{ABb}	64.88 ± 0.26^{ABb}

Mean value with a different letter in the same row (uppercase) and the same column (lowercase) was significantly different (Duncan $P < 0.05$)

it decreased to 18.29% in stage 7. These results are consistent with a decrease in starch content in 'Cavendish bananas' during ripening (Yap et al. 2017). Amylase enzymes that can degrade starch are α-amylase and β-amylase that convert starch to simple sugars (Ayo-Omogie et al. 2010).

The banana or plantain requirement used as raw materials for flour is to have a starch content of 16.5%–19.5% (Harefa and Pato 2017). Based on the data in Table 3, it can be seen that the ripening stages fulfilling the requirements for making unripe plantain flour from 'Kapas, 'Raja Bulu', 'Tanduk', and 'Siam' cultivars are in stages 1 to 3, and from 'Kepok Kuning' cultivar in stages 1 to 2. Meanwhile, the ripening level fulfilling the requirements for making ripe plantain flour from 'Kepok Kuning', 'Tanduk', and 'Siam' cultivars is in stage 4. 'Raja Bulu' cultivar is in stages 4 to 5, and 'Kapas' cultivar is in stages 4 to 7. Stage 7 is an over-ripe category but it can still be used as a raw material for flour because the starch content is still eligible (18.29%) (Table 3). This flour has high moisture content (60.65%) and high reducing sugar content (15.91%) (Tables 2 and 3), thus requiring proper drying techniques for the manufacture of ripe plantain flour in order to produce good quality flour. Each plantain cultivar at ripening stage 1–7 could be processed into flour based on the starch content.

The cultivar with the highest increase in reducing sugar levels is 'Raja Bulu'. The reducing sugar results from starch degradation during the fruit ripening process (Putra et al. 2015). The increase in sugar content during ripening is in line with what was reported by Özdemir (2016). In 'Cavendish' bananas, the total increase in sugar reached 12.28% in ripening stage 7 (Yap et al. 2017), which was lower than reducing sugar content in the plantain cultivars 'Kapas', 'Raja Bulu', 'Kepok Kuning', and 'Tanduk'.

The TSS for five plantain cultivars were 0.00 °Brix and increased to 5.50 in 'Raja bulu' cultivar and 1.50 in 'Kepok Kuning' cultivar in stage 7 (Table 2b). These results indicate that the plantain cultivar and ripening stage significantly affect changes in TSS ($P < 0.05$). The increase in TSS values in the five plantain cultivars during ripening is consistent with the research results on the 'Berangan' banana cultivar (Zulkifli et al. 2016) and 'Cavendish' banana cultivar (Yap et al. 2017).

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Table 3. The chemical content of several Indonesian plantain cultivars during ripening

Response	Stage of Ripening						
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Starch content (%)							
Kapas	34.32 ± 2.05^{Bbcd}	31.20 ± 1.43^{Be}	28.62 ± 0.56^{Bde}	26.41 ± 0.96^{Bcde}	23.77 ± 0.47^{Bbc}	20.90 ± 0.51^{Bab}	18.29 ± 0.61^{Ba}
Raja Bulu	35.03 ± 0.16^{Bbcd}	33.51 ± 0.25^{Be}	31.07 ± 1.04^{Bde}	26.56 ± 1.54^{Bcde}	20.87 ± 0.73^{Bbc}	8.38 ± 0.86^{Bab}	7.79 ± 1.60^{Ba}
Kepok Kuning	29.97 ± 0.07^{Abcd}	20.00 ± 0.32^{Ae}	16.36 ± 0.15^{Ade}	15.35 ± 0.06^{Acde}	8.58 ± 0.01^{Abc}	6.40 ± 0.98^{Aab}	3.93 ± 0.14^{Aa}
Tanduk	29.16 ± 0.28^{Abcd}	26.20 ± 0.38^{Ae}	23.94 ± 1.07^{Ade}	22.13 ± 1.53^{Acde}	15.75 ± 4.06^{Abc}	5.74 ± 3.08^{Aab}	4.61 ± 1.51^{Aa}
Siam	27.29 ± 0.33^{Abcd}	24.39 ± 0.09^{Ae}	21.02 ± 0.11^{Ade}	15.21 ± 0.05^{Acde}	13.70 ± 0.17^{Abc}	10.35 ± 0.33^{Aab}	9.12 ± 0.11^{Aa}
Reducing sugar content (%)							
Kapas	0.00 ± 0.00^{Abc}	0.00 ± 0.00^{Aa}	2.45 ± 0.01^{Aa}	6.52 ± 0.63^{Aab}	10.78 ± 0.43^{Abc}	13.25 ± 2.08^{Acd}	15.91 ± 1.44^{Ad}
Raja Bulu	0.00 ± 0.00^{Abc}	2.36 ± 0.50^{Aa}	4.32 ± 0.19^{Aa}	7.55 ± 0.96^{Aab}	12.52 ± 1.12^{Abc}	15.51 ± 0.30^{Acd}	18.20 ± 1.03^{Ad}
Kepok Kuning	0.00 ± 0.00^{Abc}	0.78 ± 1.10^{Aa}	3.31 ± 0.33^{Aa}	6.80 ± 1.50^{Aab}	9.24 ± 1.89^{Abc}	9.99 ± 1.06^{Acd}	14.81 ± 0.18^{Ad}
Tanduk	0.00 ± 0.00^{Abc}	1.77 ± 0.14^{Aa}	4.38 ± 0.54^{Aa}	8.10 ± 0.26^{Aab}	10.42 ± 0.04^{Abc}	15.07 ± 0.56^{Acd}	16.42 ± 0.46^{Ad}
Siam	0.00 ± 0.00^{Abc}	1.32 ± 0.04^{Aa}	3.36 ± 0.87^{Aa}	5.48 ± 0.41^{Aab}	6.37 ± 0.36^{Abc}	8.45 ± 2.25^{Acd}	9.01 ± 0.99^{Ad}
Total soluble solids (°Brix)							
Kapas	0.00 ± 0.00^{ABbcd}	0.00 ± 0.00^{ABa}	0.80 ± 0.28^{ABab}	1.55 ± 0.64^{ABbc}	3.10 ± 0.14^{ABcde}	4.85 ± 0.07^{ABde}	5.00 ± 0.00^{ABe}
Raja Bulu	0.00 ± 0.00^{Bbcd}	0.00 ± 0.00^{Ba}	2.15 ± 0.21^{Bab}	4.20 ± 0.28^{Bbc}	4.35 ± 0.64^{Bcde}	4.90 ± 0.14^{Bde}	5.50 ± 0.00^{Be}
Kepok Kuning	0.00 ± 0.00^{Abcd}	0.40 ± 0.00^{Aa}	0.60 ± 0.28^{Aab}	1.00 ± 0.14^{Abc}	1.20 ± 0.28^{Acde}	1.35 ± 0.07^{Ade}	1.50 ± 0.35^{Ae}
Tanduk	0.00 ± 0.00^{Abcd}	0.00 ± 0.00^{Aa}	1.10 ± 0.07^{Aab}	1.40 ± 0.14^{Abc}	1.60 ± 0.00^{Acde}	1.70 ± 0.07^{Ade}	2.60 ± 0.85^{Ae}
Siam	0.00 ± 0.00^{Abcd}	0.00 ± 0.00^{Aa}	1.25 ± 0.07^{Aab}	1.70 ± 0.00^{Abc}	2.45 ± 0.00^{Acde}	2.75 ± 0.07^{Ade}	3.75 ± 0.14^{Ae}

Mean value with a different letter in the same row (uppercase) and the same column (lowercase) was significantly different (Duncan $P < 0.05$)

CONCLUSIONS

During the ripening, there were physicochemical changes in the five Indonesian plantain cultivars. The plantain cultivars 'Kapas', 'Raja Bulu', 'Kepok Kuning', 'Tanduk', and 'Siam' were undergoing peel discoloration from green to yellow with brown spots. These cultivars showed increased weight loss, pulp to peel ratio, softness, total titrable acidity, moisture content, reducing sugar content, TSS value, decreased pH, and starch content. Based on the starch content, 'Kapas', 'Raja Bulu', 'Tanduk', and 'Siam' cultivars in ripening stages 1–3 and 'Kapas' cultivar in ripening stages 1–2 are suitable to be used as raw banana flour. In contrast, 'Kepok Kuning', 'Tanduk', and 'Siam' cultivars in stage 4, 'Raja Bulu' cultivar in ripening stages 4–5, and 'Kapas' cultivar in ripening stages 4–7 can be utilized as ripe banana flour.

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