Effect of Ripening Stage of Banana and Drying Methods on Properties of Flour for Mixed Banana Powder Drink

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Abstract

Natural drink has increasingly interested consumers. To develop the natural drink, the effect of ripening stage and drying methods on quality of banana powder were investigated. Banana at the ripening stage I, II and III was steamed at 100°C for 20 min prior to hot-air drying. Also, banana paste was dried by a rotary drum dryer at 150°C. Qualities of flour were affected by the ripening stage and drying methods. Flour from stage II banana with drum drying provided the best qualities to formulate the mixed powder drink. A mixture of 85% drum dried and stage II banana flour with 10% oat grain and 5% sesame powder obtained the highest liking scores in the case of serving at ambient temperature.

Keywords: Banana, Flour, Drying, Powder, Drink

1. Introduction

Fruits are the fundamental of a healthy diet and contain in a highly amount of nutrient. Banana holds approximately 15% of the world's total fresh fruit production. It is widely produced in tropical and subtropical regions. Banana plantation is a business with low-investment, high-efficiency, and rapid income. It plays a crucial role to become an essential industry in the rural economy. It has an important impact on the economy for developing country (Bi *et al.*, 2017). In fact, Thailand is a privileged country with a stable warm season that is great for cultivating a wide variety of tropical fruit in an entire year.

As reported by Anyasi *et al.* (2015), banana has been applied in nutritional and nutraceutical utilization by processing into flour to increase its functionality and prolong its shelf-life. It is a preferred item in the diet as it contains a considerable amount of fiber, carbohydrate, vitamins, and polyphenols with antioxidant capacity. *Musa spp.* is a type of climacteric fruit which is highly perishable and deteriorate to food spoilage very fast because of their high moisture content that is good for microbial growth and metabolic activity such as biochemical reaction.

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Enzymatic browning is a biochemical reaction which occurs during peeling of fruit and results in an undesirable effect on color and flavor of processed fruit (Anyasi *et al.*, 2015). In order to preserve the post-harvest loss, an appropriate technology for processing should be used because some pretreatments can improve its qualities. Blanching is a critical point to industrial process since it is applied to inactivate enzymes and reduce microbial load. Moreover, it also enhances the taste of fruits, including maintaining its flavor.

Furthermore, increasing in ripeness stage can decrease the starch content and elevate the level of sugar. The variation of starch content might lead to change in product quality. Importantly, the digestibility of starch has recently counted as a quality index which expresses as a glycemic index to rank their potential liberation of glucose toward the blood (Prachayawarakorn *et al.*, 2016). Therefore, it is important to identify the correct maturity for acceptable quality of the final product.

Convective drying is traditionally used to dry banana, due to its low-cost processing. However, their color properties are very poor because drying condition takes a long time that can enhance non-enzymatic Maillard browning reaction (Falade and Oyeyinka, 2015). On the other hand, drum drying can be used to dehydrate slurries, purees, and pastes by conduction. The product to be dehydrated is uniformly poured over a heated drum to evaporate moisture and then the drum blades scrape dried product. The uniformity of slurry and full attachment of samples to the drum is important to obtain a high quality and fully dehydrated product. Occasionally, the product may need some modification by adding other ingredients to ensure the above conditions are met. Particularly, its drawback is the high temperature of the drums that possibly cause severe damage to the final product (Borbi, 2016).

As mentioned above, the objective of this study was to study the effect of ripening stage of banana and drying method on physical properties of banana flours. Application of banana flour as the mixed instant powder drink was also determined.

2. Materials and Methods

2.1 Sample preparation and banana flours production

Cavendish banana (Hom Thong) was purchased from local market in Bangkok, Thailand. In this study, three ripening stages (stage I: unripe green, stage II: turning yellow and stage III: yellow) were selected, based on the preliminary study.

For hot air drying [Figure 1(a)], prior to starting each experiment, the banana was peeled and sliced into 2.5 mm thickness using a stainless-steel slicing machine (Lyounice, model no 6667, Germany). The banana slices were pretreated by steam blanching for 20 min for all ripening stages. The steam blanched sliced were drained for 2 min prior to hot air drying

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at 70°C for 8 h, 10 h and 11 h for stage I, stage II and stage III, respectively (Anyasi *et al.*, 2016). Then, samples were milled into flour.

For drum drying (scale up), the fresh banana was blended into a banana paste by a blender. The banana paste was dried by a rotary drum dryer (Model 12” × 18”). As shown in Figure 1(b), the dryer consisted of heating system by steam and the cylindrical drum of 305 mm in diameter and 457 mm in length connected to 1 hp motor. The banana paste was dried by a double heated drum that operated at 150ºC, 3.5 bar steam pressure and the rotation speed of 4 rpm. Nip feeding method and the adjustable gap between two drums were used as means to control the dried film thickness. A uniform film on the drum surface was maintained to ensure consistent final moisture content (Tang *et al.*, 2003). Then, the dried banana film was milled into flour. All flours were sieved to obtain a particle size of 150 μm and stored in the aluminum bag.

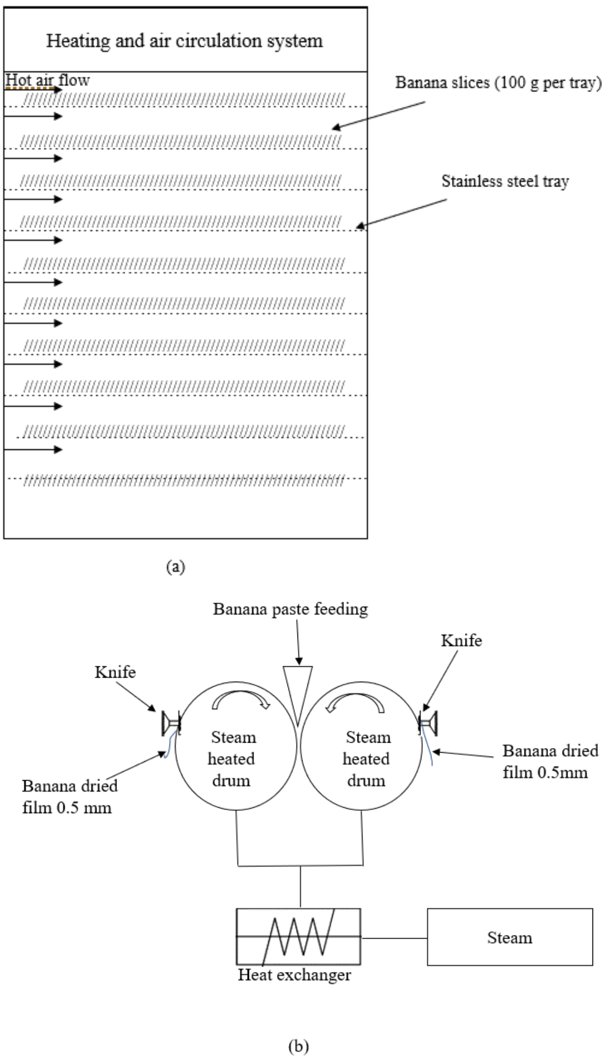

Figure 1 Schematic of a) hot-air dryer and b) double drum dryer

2.2 Analysis of flour quality

Moisture content: Approximately 2.0 g of flours were weighed accurately and dried for 2 hours at 130ºC in the hot-air oven (Model ED115/E2; Binder, Tuttlingen, Germany) (AOAC, 2000). The results were expressed as a percentage of water on a wet basis.

Water activity: Water activity (Aw) was measured by a water activity meter (Model AquaLab Series 3TE, Decagon Device, Inc., USA). Approximately 2.0 g of ground sample was placed in a container and placed in the water activity meter at 25°C.

Color profile: Color of dry flour was measured with a spectrophotometer (Model CM-3500d; Minolta, Osaka, Japan) using the CIE L*, a*, b* color space equipped with illuminant of D65 and 10° of a standard observer. *L** is a measurement of lightness from black (0) to white (100), *a** is a function of the green (negative value) to red (positive value), and *b** is a function of the blue (negative value) to yellow (positive value).

Pasting properties: Pasting profile of flours was determined by a Rapid Visco-Analyzer (Model RVA-4; Newport Scientific Pty., Ltd., Warriewood, Australia). Approximately 3.5 g of samples and 25 ml of distilled water was added, heated to 50°C and hold for 1 min. Then, it was heated to 95°C at a rate of 6°C/min and hold at this temperature for 5 min. The samples were then cooled to 50°C at a rate of 6ºC/min (Suriya *et al.*, 2017). The maximum and cooling viscosity was recorded.

Water absorption capacity (WAI) and water solubility (WSI): WAI and WSI were determined as described by (Kumar and Saini, 2016) with some modifications. To determine WAI, 1 g of each sample would suspend in 10 ml of distilled water at ambient temperature in a tarred centrifuge tube. The suspension was stirred in a Vortex mixer for 1 min, put for 30 min in a water bath at 30ºC, and then centrifuged at 3000 rpm for 15 min. The liquid supernatant was poured into a tarred evaporating dish of known weight and dried at 130°C to constant weight. The weight of the remaining gel was taken as WAI and expressed in g of water per g of dry sample. The amounts of dried solids were recovered by evaporating the supernatant from the WAI analysis and expressed as a percentage of dry solids for WSI.

Swelling power (SP): 1g of flour was mixed with 10 ml of distilled water in a centrifuge tube and heated at 80°C for 30 min with shaking continuously. The tubes were removed and cooled to room temperature. Upon cooing, samples were centrifuged at 3000 rpm for 15 min. The liquid supernatant was decanted. Weight of the puree was then determined.

2.3 Mixed banana powder drink formulation

Mixed instant powder was formulated by mixing the banana flour with oat grain and sesame powder, using ratios from mixture design listed in Table 1.

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Table 1 Formulation of mixed banana powder drink by mixture design

Treatment	Ingredients		
	Banana flours (%)	**Oat grain (%)**	**Sesame powder (%)**
F1	100	0	0
F2	85	10	5
F3	75	10	15
F4	65	30	5
F5	80	15	5
F6	80	10	10
F7	70	25	5
F8	70	15	15
F9	60	30	10
F10	60	25	15

2.4 Determination of quality of mixed banana powder

The formulated products were analyzed on physical properties such as moisture content (AOAC, 2000), water activity by a water activity meter (Model AquaLab Series 3TE, Decagon Device, Inc., USA) and color profile by a spectrophotometer (Model CM-3500d; Minolta, Osaka, Japan).

2.5 Sensory analysis

Sensory evaluation: Sensory qualities of the samples were evaluated in terms of color, appearance, aroma, taste, flavor and overall liking. Each attribute was evaluated using a 9-point hedonic scale, where 9 is extremely like and 1 is extremely dislike. Untrained panelists (n=30) were used for testing. Samples (with a ratio of powder: water = 1:5) were served at warm (60–70ºC) and ambient temperature.

2.6 Statistical analysis

One-way analysis of variance (ANOVA) was applied to all data by using SPSS 12.0 statistical package (SPSS Inc., Chicago, IL, USA). Duncan's Multiple Range Test was used to determine statistically significant difference between the means. P-value <0.05 was considered as the significant difference for the comparison. All analysis was done in triplicate. The result was presented as mean±standard deviation (SD).

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3. Results and Discussion

3.1 Drying kinetic

Banana slices were dried from initial moisture content of 2.373, 2.358 and 2.598 g water/ g dry matter to final moisture content of 0.009, 0.006 and 0.009 g water/ g dry matter for hot air dried banana stage I, II and III, respectively. Figure 2 indicated about the changes in moisture ratio with drying time of banana sliced. The time required for hot air drying were 8 h, 10 h and 11 h at 70ºC for stage I, II and III, respectively. According to Figure 2, at the initial stages of the drying process, the drying rates were high. With an increase in time, the drying rates decreased and until the samples reached the equilibrium moisture content indicated by a constant weight. The reason for this phenomenon is due to the migration of water out of the sample.

Firstly, the surface of the samples was heated up and the free water moved out of the samples and evaporated, following a constant rate of drying. With increasing time, water moved from the interior of the food to the surface following a falling rate of drying (Ma *et al.*, 2017). Drying rate of stage III banana was faster than others at the beginning of drying. However, as a steamed banana, a lower drying rate of banana stage II and III were occurred due to gelatinization of starch during steaming.

During steaming process, the heat energy broke the hydrogen bonds and water was absorbed into starch granule. A formation of hydrogen bonds with amylose and amylopectin occurred and the amount of free water outside granule decreased (Ma *et al.*, 2017). Thus, a limit mobility of moisture during drying occurred for stage I and II banana, resulting in lower drying rate than stage III banana. On the other hand, banana at the ripening stage I had a shorter drying time than that at the ripening stage III. These results were attributed to the different initial moisture contents, and different amounts of disaccharide and monosaccharides that caused a resistance to movement of moisture travelling from the interior to the sample surface by a combination of bound water and sugar (Prachayawarakorn *et al.*, 2016).

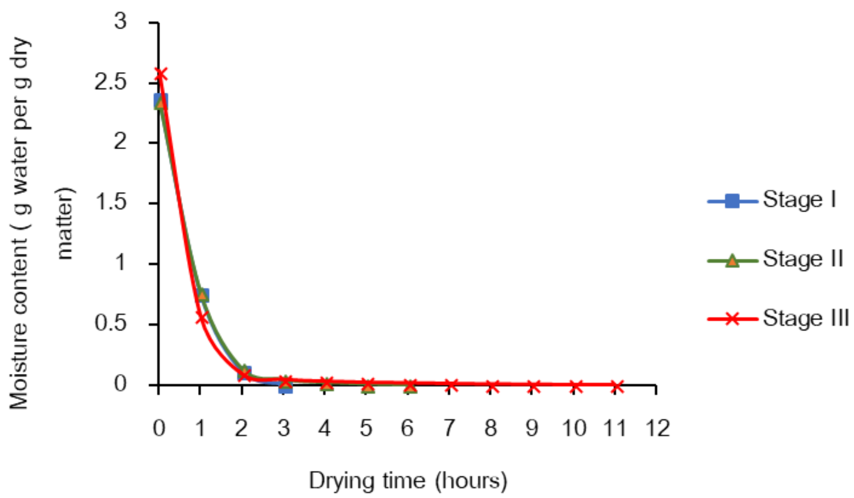

Figure 2 Changes in moisture content of banana slices during hot-air drying process

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3.2 Moisture content and water activity of banana flours

Change in moisture content of banana flour subjected to different treatments was shown in Table 2. Moisture content and water activity of flours were in a range of 7.56–13.77 % wb and 0.235–0.441, respectively. Moisture content tended to increase with an increase in ripening stage of banana. With an increase of maturity, starch was gradually disappeared with sugar accumulation by transformation which involved with several enzymes and path ways. Thus, higher amounts of disaccharide and monosaccharides accumulation could cause a resistance to movement of moisture travelling from the interior to the sample surface by a combination of water and sugar (Cordenunsi and Lajolo, 1995; Prachayawarakorn *et al.*, 2016). These results were consistent with the previous work done by Sahoo *et al.* (2014) and Prachayawarakorn *et al.* (2016) which stated that the moisture content of banana was increased, depending on the steaming time and maturity of banana. The increase in moisture content during steaming step attributed to the partial disruption of sample cells and swelling of banana starch which allowed more water absorption. Furthermore, the starch gelatinization could limit mobility of moisture content during drying; thereby, moisture content in the hot air dried banana flours seemed higher than drum dried flours. However, in this study, water activity of all banana flour was lower than 0.6. It indicated that all of the samples were considered adequate for food preservation. In addition, all drying methods applied in this study were acceptable to prolong shelf-life of banana.

Table 2 Moisture content and water activity of banana flour

Treatment	MC (% wb)	Water activity
Hot-air dried stage I	7.79 ± 0.07^{e}	0.411 ± 0.011^{b}
Hot-air dried stage II	11.31 ± 0.09^{c}	0.441 ± 0.002^{a}
Hot-air dried stage III	13.77 ± 0.20^{a}	0.368 ± 0.01^{c}
Drum dried Stage I	7.56 ± 0.09^{f}	0.419 ± 0.001^{b}
Drum dried Stage II	8.77 ± 0.01^{d}	0.278 ± 0.001^{d}
Drum dried Stage III	11.78 ± 0.11^{b}	0.235 ± 0.004^{e}

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$).

3.3 Color profile of banana flours

Upon pretreatment of banana samples with steam blanching and drying at different methods, the a* and b* values were varied significantly ($p \leq 0.05$) of all ripening stage between both drying methods. Hot air dried stage I showed the highest L*-value (81.94±0.32) and lowest a*-value (0.90±0.05), b*-value (10.31±0.50), while Hot-air dried stage III had the lowest value in L*-value (75.02±0.01) and the highest in b*-value (25.11±0.13). According to Savlak

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et al., (2016), the increase in L*-value and decrease in a*-value and b*-value was attributed to the loss of pigment during milling process. Moreover, the decrease in yellowness may be associated with a decrease in protein content. It could refer that banana stage III contained higher protein than others. However, the value was fluctuated at banana stage II with the drum drying. It could be attributed to the change in banana color during processing steps that caused by the browning reaction. As shown in Table 3, drying process caused considerably changed in color by a longer drying time of hot air drying process. The lightness value fell to 75.02±0.01 while the yellowness (b*) and redness (a*) values increased to 25.11±0.13 and 2.58±0.01, respectively. These results showed that long drying time tended to cause color changes (Tarhan *et al.*, 2010).

Table 3 Color of banana flour

Treatment	L*	a*	b*
Hot-air dried stage I	81.94±0.32^{a}	0.90±±0.05^{f}	10.31±0.50^{f}
Hot-air dried stage II	77.75±0.02^{b}	2.39±0.02^{e}	20.39±0.18^{b}
Hot-air dried stage III	75.02±±0.01^{d}	2.58±0.01^{d}	25.11±0.13^{a}
Drum dried Stage I	75.79±0.13^{c}	4.92±0.07^{a}	17.22±0.21^{e}
Drum dried Stage II	77.62±0.25^{b}	4.22±0.06^{c}	18.40±0.13^{d}
Drum dried Stage III	75.94±0.18^{c}	4.62±0.13^{b}	19.73±0.31^{c}

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$).

3.4 Pasting properties of flours

Pasting temperature indicates the temperature require to cook the flour after its gelatinization point. It is the temperature at which the first detectable increase in viscosity is measured. It is an index characterized by the initial change due to the swelling of starch (Bakare *et al.*, 2017). As shown in Table 4, pasting temperature of the flour from stage I and stage II banana with drum drying ranged from 62.35±6.44ºC to 75.28±4.42ºC. However, pasting profiles of flour from stage III banana with both drying methods were non-detectable. These results were associated with the presence and structure of starch molecules. Previous studies reported that the decrease in gelatinization was due to the loss of starch crystallinity with an increase in ripening stage. The steaming could cause the disappearance of crystalline structure, Thus, non-detectable gelatinization after steaming indicated the complete gelatinization of banana starch (Prachayawarakorn *et al.*, 2016).

Peak viscosity is the maximum viscosity developed during or soon after the heating phase of the test. It occurs after most of the granule swelling had ceased. Hot starch paste is a mixture of swollen starch granules and granule fragments, together with colloidal and molecularly dispersed starch molecules. It gelatinizes when heated beyond 50ºC. This caused a marked increase in viscosity and further disintegration of starch granules. Therefore, a higher value of RVU at the peak of curve indicated a lower diastatic activity and vice versa (Bakare *et al.*, 2012). The peak viscosity of stage I banana with hot air drying (266.05±17.15 RVU) was found to be significantly lower than that of drum drying (390.33±56.21 RVU). This result showed that hot-air dried flour had a higher diastatic activity and lower gel strength than the drum dried flour, for the stage I banana (Bakare *et al.*, 2017).

Breakdown viscosity is the measurement of the degree of starch disintegration. It is an indication of hot paste stability of the starch. The smaller the breakdown viscosity, the higher paste stability is (Alcázar-Alay and Meireles, 2015). Flour from stage II banana with hot air drying had significantly lower (12.66±2.08) breakdown viscosity than other flours (48.66±28.93 to 78.00±52.88). It illustrated that the hot air dried flour from stage II banana had better hot paste stability than other flours (Bakare *et al.*, 2017).

Final viscosity is the section of the paste gel curve where the gelatinized dispersion of starch becomes viscoelastic on cooling, resulting in the formation of a loose paste or gel. In the current study, the final viscosity of flour ranged from 94.00±26.90 to 672.00±112.40 for drum dried flour from both stage I and II and stage I. This indicated that the drum dried flour from stage I banana formed a firmer gel after cooking and cooling (Bakare *et al.*, 2017).

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Table 4 Pasting properties of banana flour

Treatment	Peak 1	Trough 1	Breakdown	Final Viscosity	Set back	Peak Time	Pasting Temp
Hot-air dried stage I	266.05±17.15^{b}	214.77±4.45^{b}	51.27±12.98^{ab}	218.86±4.79^{b}	4.08±±1.30^{b}	6.08±0.10^{a}	63.10±0.51^{b}
Hot-air dried stage II	92.33±4.72c	79.66±4.04^{c}	12.66±2.08^{b}	179.66±5.13^{bc}	100.00±2.00^{b}	6.64±0.50^{a}	65.56±4.47^{b}
Hot-air dried stage III	ND	ND	ND	ND	ND	ND	ND
Drum dried Stage I	390.33±56.21a	312.33±22.50^{a}	78.00±52.88^{a}	672.00±112.40^{a}	359.66±119.55^{a}	6.91±0.10^{a}	62.35±6.44^{b}
Drum dried Stage II	88.33±25.00c	39.66±4.16^{d}	48.66±28.93^{ab}	94.00±26.90^{c}	54.33±25.00^{b}	5.88±±0.91^{a}	75.28±4.42^{a}
Drum dried Stage III	ND	ND	ND	ND	ND	ND	ND

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$). ND: Not detect

3.5 Water absorption index, water solubility index and swelling power of banana flours

Water absorption index (WAI) is a measurement of the volume occupied by the starch granule after swelling in excess of water. For instance, water solubility index (WSI) determines the amounts of free molecules leached out from the starch granule in addition to excess water. The swelling power (SP) and solubility are good parameters to evaluate the integrity of the starch granule. The solubility is related to the amounts of soluble solids in the dry sample, enabling the application of treatments which depend on gelatinization, dextrinization and the consequent solubilization of starch (Savlak *et al.*, 2016). The value of water absorption index, water solubility index and swelling power of banana flours were shown in Table 5. Drying method had no significant effect on WAI of flour samples obtained from stage III banana. For the stage II and stage III banana, WAI was not significantly different, when hot air drying was used. However, flours from both drying methods showed significant difference in WSI across maturity stage. According to Table 5, the highest WAI (4.03±0.05 g/g dry sample and 7.91±0.27 g/g dry sample) in stage I banana from both drying methods were in conformity with the discovery of Anyasi *et al.* (2015), which reported that WAI was basically influenced by the extent of disintegration of native starch granules, physical state of starch, dietary fiber and protein content in the unripe flour (stage I). Results of WAI, WSI obtained from this study were similar to those reported by Bezerra *et al.* (2013), Anyasi *et al.* (2015), Savlak *et al.* (2016) and Alkarkhi *et al.* (2011). However, drum dried stage I banana flour had the highest value of WAI (7.91±0.27 g/g dry sample), SP (9.09±0.19 g/g dry sample) and the lowest value of WSI (10.25±0.41%), while flour from stage III banana had the lowest WAI values (2.92±0.02 g/g dry sample and 3.21±0.14 g/g dry sample). Falade and Oyeyinka (2015) mentioned that water absorption capacity of dried flour was decreased with the increased maturity. In addition, soluble solids and sugars content increased while the starch content of banana decreased with the increased maturity. Thus, higher starch content would facilitate the increase in water absorption in banana flour. According to Alkarkhi *et al.* (2011), amylose has the capacity to bind water molecules, yielding a higher WAI. Nevertheless, the low value of hot-air dried stage III banana was related to lower starch content in the ripe banana (stage III). Therefore, WAI value of stage III flour could attribute to the dietary fiber and protein content.

Swelling power (SP) was within the range of 3.52±0.27 g/g dry sample to 9.09±0.19 g/g dry sample. There was no significant difference in SP of stage III banana across drying method. However, a significant difference was recorded in SP of stage I and stage II banana from both drying methods. The swelling power of this study was lower than the previous discovery which done by Bezerra *et al.* (2013). It could be attributed to the temperature of the

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process that caused the hydrogen bonds broken and water molecules were bound to hydroxyl groups released. Furthermore, the granule expanded and amylose was exuded.

Table 5 WAI, WSI and SP of banana flour

Treatment	WAI ($g.g^{-1}$ dry sample)	WSI (%)	SP ($g.g^{-1}$ dry sample)
Hot-air dried stage I	$4.03±0.05^{c}$	$13.97±0.52^{c}$	$8.55±0.31^{b}$
Hot-air dried stage II	$2.88±0.02^{e}$	$35.41±0.17^{b}$	$5.59±0.16^{d}$
Hot-air dried stage III	$2.92±0.06^{de}$	$45.70±4.27^{a}$	$3.81±0.14^{e}$
Drum dried Stage I	$7.91±0.27^{a}$	$10.25±0.41^{c}$	$9.09±0.19^{a}$
Drum dried Stage II	$5.42±0.24^{b}$	$38.64±0.08^{b}$	$6.21±0.08^{c}$
Drum dried Stage III	$3.21±0.14^{d}$	$44.34±5.03^{a}$	$3.52±0.27^{e}$

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$)

3.6 Quality of instant mixed powder drink

Products were formulated with different ratio of ingredients. A study was conducted to select the best formula to develop a new product with acceptable qualities. Table 6 illustrated that moisture content of the formulated samples was range from 7.83±0.14 to 8.97±0.07 % wb. F4 had the highest moisture content (8.97±0.07 % wb), due to a large amount of oat grain (30%) and banana flour (65%).

Water activity of the formulated products was not significantly different, except F1 and F2. Since a formulation was made of drum dried stage II banana with other ingredients, variation of moisture content and water activity was associated with the ratio of ingredients. Interestingly, the color value (L*, a*, b*) was significantly different across all samples. The first formulation (F1) had the highest L*-value. That meant a reduction of banana flour ratio decreased the lightness of products.

Liking scores of samples that served at a warm temperature ranged from 4.5 to 6.3 for all attributes (Table 7). Liking scores of the mixed powder formulated from F2 (85:10:5), F5 (80:15:5) and F7 (70:25:5) of banana flour, oat grain and sesame powder were at a high level and not significantly different. In the formulation with dropping of banana flour ratio, the less liking of the product was obtained.

By selecting the most liking formula, 3 samples were served at room temperature to compare the liking scores. Formula F2 had the highest liking score in all attributes except sesame flavor (Table 8). Comparing with serving at a warm temperature, the panelists mostly

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liked serving the mixed banana drink at ambient temperature, due to the observed highest score of liking.

Table 6 Quality of the instant mixed powder

Treatment	MC (% wb)	Water activity	Color value		
			L*	a*	b*
F1	8.77±0.01^{ab}	0.278±0.001^{e}	77.62±0.25^{a}	4.22±0.06^{a}	18.40±0.13^{a}
F2	8.57±0.10^{bc}	0.298±0.003^{d}	75.48±0.03^{c}	3.71±0.03^{b}	17.90±0.05^{b}
F3	7.83±0.14^{e}	0.322±0.005^{c}	71.63±0.11^{h}	2.58±0.04^{f}	15.38±0.25^{g}
F4	8.97±0.07^{a}	0.345±0.004^{a}	74.50±0.18^{e}	3.41±0.06^{cd}	17.55±0.13^{c}
F5	8.50±0.14^{c}	0.324±0.004^{bc}	76.00±0.05^{b}	3.46±0.07^{c}	17.28±0.02^{d}
F6	8.15±0.12^{d}	0.333±0.006^{b}	75.15±0.18^{d}	2.99±0.07^{e}	16.29±0.03^{f}
F7	8.57±0.09^{bc}	0.324±0.003^{c}	76.18±0.05^{b}	3.36±0.03^{d}	16.97±0.03^{e}
F8	8.00±0.17^{de}	0.323±0.005^{c}	72.42±0.10^{g}	2.48±0.05^{g}	14.97±0.17^{h}
F9	8.54±0.19^{bc}	0.331±0.006^{bc}	72.99±0.18^{f}	2.39±0.04^{g}	15.02±0.18^{h}
F10	8.21±0.13^{d}	0.325 ±0.001^{bc}	71.11±0.22^{i}	2.00±0.07^{h}	13.91±0.09^{i}

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$).

Table 7 Liking score of banana powder drink served at warm temperature (60–70ºC)

Treatment	Sensory attributes						
	Appearance	Color	Banana flavor	Sesame flavor	Overall flavor	Taste	Overall liking
F2	5.2±1.7^{ab}	5.4±1.5^{a}	6.2±1.2^{ab}	6.1±1.3^{a}	6.0±1.3^{a}	6.2±1.3^{a}	5.8±1.4^{a}
F3	4.8±1.5^{ab}	4.9±1.7^{ab}	5.2±1.6^{c}	5.3±1.6^{ab}	4.9±1.5^{c}	5.1±1.6^{bc}	4.8±1.5^{b}
F4	5.3±1.8^{ab}	5.5±1.5^{a}	5.6±1.4^{abc}	5.6±1.3^{ab}	5.4±1.5^{abc}	5.4±1.6^{abc}	5.4±1.5^{ab}
F5	5.2±1.5^{ab}	5.3±1.7^{ab}	6.3±1.2^{a}	5.8±1.2^{ab}	6.1±1.3^{a}	6.2±1.3^{a}	5.8±1.5^{a}
F6	5.1±1.6^{ab}	4.8±1.9^{ab}	6.0±1.6^{abc}	5.5±1.8^{ab}	5.4±1.7^{abc}	5.6±1.9^{abc}	5.5±1.8^{ab}
F7	5.6±1.4^{a}	5.6±1.4^{a}	5.9±1.3^{abc}	5.8±1.5^{ab}	5.8±1.5^{ab}	6.0±1.5^{ab}	5.8±1.6^{a}
F8	4.5±1.9^{b}	4.5±2.0^{b}	5.5±1.3^{abc}	5.2±1.5^{b}	5.1±1.3^{bc}	5.0±1.5^{c}	4.9±1.4^{b}
F9	5.1±1.6^{ab}	5.0±1.6^{ab}	5.3±1.4^{c}	5.4±1.4^{ab}	5.2±1.3^{abc}	5.2±1.3^{bc}	5.1±1.2^{ab}
F10	4.9±1.8^{ab}	4.7±1.7^{ab}	5.4±1.1^{bc}	5.2±1.5^{ab}	5.3±1.4^{abc}	5.1±1.5^{bc}	5.2±1.4^{ab}

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$).

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Table 8 Liking score of banana powder drink served at ambient temperature

Treatment	Sensory attributes						
	Appearance	Color	Banana flavor	Sesame flavor	Overall flavor	Taste	Overall liking
F1	5.7±1.2[b]	5.7±1.1[a]	6.2±1.2[a]	6.4±1.0[a]	6.4±1.1[a]	6.3±1.3[a]	6.1±1.2[a]
F2	6.4±0.9[a]	6.3±1.1[a]	6.5±1.2[a]	5.7±1.0[b]	6.4±1.0[a]	6.5±1.1[a]	6.3±1.1[a]
F5	5.8±1.2[b]	5.5±1.5[a]	6.2±1.2[a]	6.3±0.9[a]	6.4±0.8[a]	6.4±1.1[a]	6.0±1.1[a]

Note: Different superscript letters at each column indicate significant differences ($p \leq 0.05$).

4. Conclusion

In this study, the effect of ripening stage of banana and drying methods were investigated. Banana slices were dried using a hot air dryer and a rotary drum dryer. Scaling up by drum drying could reduce drying time and produce better qualities in term of moisture content, water activity, color, water absorption, water solubility and swelling power for stage II banana. An increase in higher ripening stage caused longer drying time, and darker flour of banana due to browning reaction. Thus, it was confirmed that different stages of banana ripeness and drying methods gave the strong impact to the banana powder quality. To develop banana flour, the drum drying with stage II banana was recommended as the best formula. Based on the results, the formulation of 85% banana flour was preferred. In addition, a temperature of serving has an effect on the likeness of the banana flavor of the mixed powder drink.

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