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Inhibition of the Enzymatic Browning Reaction in Dried Pisang Mas Banana

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Abstract

Enzymatic browning is a major concern in dried Pisang Mas bananas impacting customer satisfaction. Herein, we aimed at developing the methods to inhibit the browning reaction of dried Pisang Mas bananas. The pretreated dried Pisang Mas bananas were evaluated using the color comparison with the commercial products. The results showed the pretreatment of Pisang Mas bananas with the optimum conditions of ascorbic acid at pH 5.5 for 20 min and citric acid at pH 4.5 for 10 min had the ability to inhibit the browning reaction that improved banana's color closing to the color of the commercial products. Moreover, we proposed pineapple juice and saline solution as the available and low-cost approach to resolve the browning problem. The results showed pretreating Pisang Mas bananas with pineapple juice at pH 4.0 for 10 min and 0.5% w/v saline solution for 20 min was able to inhibit the browning reaction. This finding would be useful for increasing dried banana cost that will be further beneficial to society, economics, and database information.

Keywords: Pisang Mas bananas, Browning reaction inhibition, Drying technology, Pretreatment process

1. Introduction

Pisang Mas bananas are the well-known Thai fruit gaining the popularity from both Thai and foreigners. Consequently, Pisang Mas bananas have continuously made high export revenue to Thailand (1). The exported amount of Pisang Mas banana had annually increased during 2013-2019. In 2019, Pisang Mas was exported up to 15 million kilograms (413 million baht) (2). In addition to good taste, Pisang Mas bananas contain high nutrition, especially ß-carotine (3), and high antioxidant activity (19.39 mg TE/g d.w. for DPPH assay) (4) that was higher than that in some berries. Moreover, phytosterol in the bananas can decrease cholesterol level in blood (5).

According to huge benefit, Pisang Mas bananas are usually persevered for long storage and additionally increasing their costs. However, the key problem impacting the preservation method is the dark-brown color appearing on their skin resulting in lowering customer satisfaction. The dark-brown color is developed by the browning reaction that usually occurs when the fruit is physically broken such as cutting, peeling off, or mashing. The oxidation reaction between monophenol in fruit and oxygen produces brown pigments. This reaction undergoes with an enzymatic catalyst, polyphenol oxidase, as shown in Figure 1 (6).

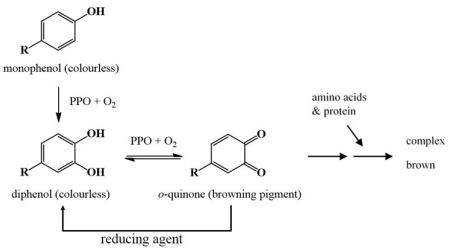

Figure 1 The browning reaction

The inhibitory methods for browning reaction were previously proposed. For example, sulfite was used to reduce the browning reaction; however, high toxicity of this compound makes customers concerns (7). Safer alternative methods were proposed to inhibit polyphenol oxidase such as using ascorbic acid, glutathione, and cysteine. These reducing agents can convert othoquinone to colorless othodiphenol resulting in improving product color

(8). Besides the above mentioned compounds, citric acid was proposed to provide the unworkable condition for polyphenol oxidase. In addition, citric acid can bind with copper in the enzyme structure leading to suppress the browning reaction (9). Here, we aimed at developing the methods including ascorbic acid and citric acid pretreatment to reduce enzymatic browning in dried Pisang Mas bananas. Moreover, we also introduced the low-cost, simple, and readily available approach including pineapple juice and saline solution for solving the browning reaction. The proposed methods will be further applied for large scale production of dried Pisang Mas bananas to increase the value of the products.

2. Materials and Experiment

2.1 Materials

Ascorbic acid, citric acid, and sea salt (food grade) were purchased from local markets. Pineapple juice was purchased from Malee Applied Sciences (Thailand). Distilled water was used for all experiments.

2.2 Dried Pisang Mas bananas

Ripe Pisang Mas bananas (130-140 days) were dried at 60 degrees Celsius for 12 hrs using a hot air oven purchased from Eureka (Thailand). Five bananas were randomly selected for each experiment. All experiments were repeated for 3 times. The color code of dried bananas from each experiment was investigated by using Royal Horticultural Society (RHS) color charts (10). The color code of commercial dried bananas is 163B, which was used as the standard color for all experiments.

2.3 Effect of air exposure before the drying process

The effect of air exposure time was studied by leaving peeled bananas at room temperature for 10, 15, and 20 min prior to starting the drying process. The color code of dried Pisang Mas bananas was determined using the RHS color charts.

2.4 Effect of ascorbic acid, citric acid and pineapple juice for dried banana pretreatment

Peeled Pisang Mas bananas were soaked in 1% w/v ascorbic acid, 1% w/v citric acid, and 100% pineapple juice at pH 3.5, 4.0, 4.5, 5.0, and 5.5 for 10 and 20 min (11-12). pH was adjusted using distilled water. The pretreated bananas were taken to the drying process. The color code of dried Pisang Mas bananas was determined using the RHS color charts.

2.5 Effect of saline solution

Peeled Pisang Mas bananas were soaked in 0.5% w/v saline solution for 10 and 20 min. The pretreated bananas were taken to doing drying process. The color code of dried Pisang Mas bananas was determined using the RHS color charts.

3. Results and Discussion

3.1 Effect of air exposure before the drying process

The standard commercial dried banana (Figure 2a) obtained the 163B color code in the RHS charts (Figure 2b). However, the browning reaction caused dark-brown color of bananas as shown in Figure 2c that would reduce customer satisfaction. Exposure to the air from physical broken can generate the browning reaction in Pisang Mas bananas. Time of air exposure was studied to monitor the presence of the browning reaction. The time of peeled Pisang Mas bananas stored at room temperature before the drying process was varied between 10 and 20 min. The results showed although the bananas were left at room temperature at different periods of time, the appearance of developed dark-brown color (Table 1) was similar because the reaction still occurred during the drying process that could not avoid air exposure.

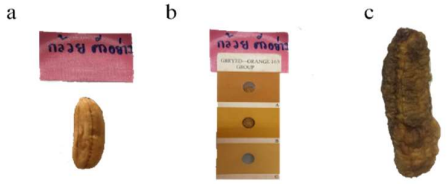

Figure 2 (a) A commercial dried banana. (b) RHS charts. (c) A dark-brown dried banana.

3.2 Effect of ascorbic acid, citric acid and pineapple juice for dried banana pretreatment

The pretreatment procedures with ascorbic acid, citric acid, and pineapple juice were introduced. The optimum conditions including pH and pretreatment time of each solution were studied as shown in Table 1. Dried Pisang Mas bananas pretreated using ascorbic acid at pH 5.0 and 5.5 for 20 min obtained the 163B color code, which was similar to the color code of commercial Pisang Mas bananas. However, when considering the ease of pH adjustment, pretreatment with ascorbic acid at pH 5.5 would be further used. In terms of citric acid, 163B color of dried Pisang Mas bananas was achieved when using citric acid pH 4.5 for 10 min and pH 5.0 for 20 min. Citric acid pH 4.5 for 10 min was the optimum condition because it took shorter time to improve the product color than using 20 min. The capability of ascorbic acid to improve the browning reaction is attributional to the binding of ascorbic acid at the active site of polyphenol oxidase resulting in browning inhibition (11). For citric acid, it is able to decrease pH that is not suitable for enzyme. Moreover, citric acid can bind with copper in polyphenol oxidase resulting in suppressing enzymatic activity (12,13) Therefore, both ascorbic acid and citric acid resolved the browning reaction of dried Pisang Mas bananas.

Table 1 Color codes of dried Pisang Mas bananas. The background color refers to the color appearance of that code

pH	Time (min)	Average Color Code					
		Control	Air exposure	Ascorbic acid	Citric acid	Pineapple juice	Saline solution
-	-	199C	-	-	-	-	-
-	10	-	199C	-	-	-	-
-	15	-	199C	-	-	-	-
-	20	-	199B	-	-	-	-
-	10	-	-	-	-	-	199C
-	20	-	-	-	-	-	163B
3.5	10	-	-	164D	164D	-	-
	20	-	-	164D	164D	-	-
4.0	10	-	-	163C	163C	163B	-
	20	-	-	164D	164D	163C	-
4.5	10	-	-	163C	163B	163B	-
	20	-	-	164D	164D	163A	-
5.0	10	-	-	199C	199C	199C	-
	20	-	-	163B	163B	163B	-
5.5	10	-	-	199B	199B	199D	-
	20	-	-	163B	163C	163C	-

Ascorbic acid and citric acid had the potential to improve the browning reaction; however, the amount of both compounds for using in food was limited due to safety concerns. Therefore, this work proposed a simpler, safer, and cheaper alternative approach using pineapple juice to pretreat Pisang bananas. Pineapple juice, which has normal pH at 3.5, was hypothesized to have the tendency for solving the browning reaction because pineapple juice consists of both ascorbic acid and citric acid, which were previously proved to inhibit the browning reaction (14-16). Furthermore, pineapple juice contains cysteine and sulfhydryl, which can solve enzymatic browning (17). According to the results (Table 1), the color code of 163B was obtained when pretreating Pisang Mas bananas with pineapple juice at pH 4.0 for 10 min, pH 4.5 for 10 min, and pH 5.0 for 20 min. However, when considering the suitability of adjusting pH and pretreatment time, the optimum condition of pineapple juice to improve the browning reaction was pH 4.0 for 10 min.

Additionally, pH and pretreatment time affected color of dried Pisang Mas bananas. The banana pretreatment with ascorbic acid at pH lower than 4.5 and citric acid at pH lower than 4.0 produced pale-yellow color (Table 1 and Figure 3a). The reason contributed to this phenomenon is that higher acidity (low pH) brings about strong inhibition of the browning reaction and deterioration of banana skin (12). Aside from pH, the pretreatment time was influential on improvement of the browning reaction as shown in Table 1. Dried Pisang Mas bananas pretreated with ascorbic acid and citric acid at both pH 5.0 and 5.5 for 10 min appeared brown color on their skin because short period of time was not enough to inhibit the browning reaction. When increasing the pretreatment time to 20 min, the standard 163B color was obtained. Therefore, pH and pretreatment time of each method affected the browning reaction inhibition.

3.3 Effect of saline solution

Saline solution was another simple approach to inhibit the browning reaction (18). The browning reaction of dried Pisang Mas bananas was solved when using saline solution pretreatment for 20 min as shown in Table 1. Shorter time (10 min) could not resolve the problem. The previous report indicated that saline solution could inhibit the browning effect by maintaining higher antioxidant activity and reducing moisture content (18).

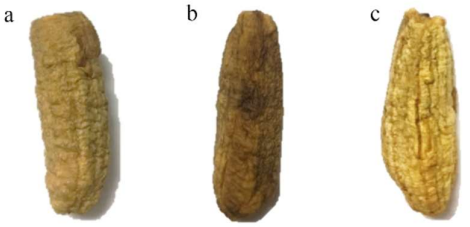

Figure 3 Appearance characteristic of dried Pisang Mas bananas pretreated with ascorbic acid at (a) pH 4.0 for 20 min (b) pH 5.0 for 10 min (c) pH 5.0 for 20 min.

4. Conclusions

The approach to resolve browning in dried Pisang Mas bananas was proposed. Pretreatment of the dried bananas with ascorbic acid, citric acid, pineapple juice, and saline solution was investigated. pH and pretreatment time affected color improvement of the products. Pretreatment of dried Pisang Mas bananas with ascorbic acid at pH 5.5 for 20 min, citric acid at pH 4.5 for 10 min, pineapple

juice at pH 4.0 for 10 min, and 0.5% w/v saline solution for 20 min materialized the goal of simply solving enzymatic browning. The proposed procedures will be further beneficial to commercial production of dried Pisang Mas bananas that can increase the product value.

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Declaration of conflicting interests

The authors declared that they have no conflicts of interest in the research, authorship, and this article's publication.

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