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Effects of ripening level and puffing temperature on qualities of puffed Homtong banana slices

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Abstract

The porosity is an important characteristic of the crispy food. Puffing technique is one of the various methods that creating the porosity in crispy product. However, the reports of effect of ripening level is still limit. Therefore, the objective of this research was to investigate the effects of ripening level and puffing temperature on puffed Homthong banana slices. The ripening level of Homthong banana was selected at 16 – 18, 20 – 22, and 24 – 26 ºBrix. Homthong-banana was sliced into 2.50 mm thickness. Then they were blanched by hot water for 30 s. After that, they were dried in 3 steps. First of all, hot air drying at 90 ºC was used to dry the samples until 35% dry basis (d.b.) moisture content. Then, they were puffed by high temperature hot air at 130, 150, and 170 ºC for 2 min. Finally, the puffed samples were dried again by hot air at 90 ºC to 4% d.b. The puffed product qualities were considered in terms of colour, texture, volume ratio. The results showed that higher ripening level provided fructose and glucose contents increased, and then resulting in more browning occurred on puffed banana surface. The higher ripening level provided lower hard texture of puffed product because pectin content tend to lower. Moreover, the puffed samples showed lower hard texture and browner colour as higher puffing temperature. The optimal condition of puffed Homthong-banana slices was 150 ºC of puffed temperature and 16-18 ºBrix of ripening level for producing crisp banana. The overall preference of puffed banana was lower than that commercial product.

Keywords: Crisp banana; Puffing; Ripening level; Volume ratio; Low fat snack

1. Introduction

Bananas are commercial crop that are consumed around the world. They have many varieties, however, one of the most famous variety is Homthong banana. Since they have rich in many kinds of vitamins (vitamin A, B, and C), mineral (potassium) and nutrient (available sugar and dietary fibre). Those nutrients can reduce the risk of high blood pressure, heart disease, colon cancer, and obesity [1]. Thus, fresh bananas are usually consumed as a healthy diet food. In the harvesting season, they are often oversupply and easy to decay resulting in lower their values. In order to maximize the shelf life and add value, bananas are processed to several products such as pureed banana, dried banana and fried banana. Especially, fried banana, which is popular product in snack market, are usually produced by deep-fat frying. Fried product is usually popular since their impressive appearance and high crispiness caused by frying technique which provided high porosity. However, the drawback of fried product is high fat content and short shelf life which caused by the oxidation reaction [2].

A hot air drying method is a simple process which can produce the low-fat fruit chips. However, this method is usually used low temperature and long drying time resulting in high volume shrinkage and then texture become harder as compared with commercial product. A puffing technique is an alternative method for producing healthy crispy snack and can improve the qualities of product [1, 3]. This technique is high-temperature and short-drying-time process which stimulated the rapid evaporation of inside moisture content to the surface in very short time [4, 5]. As a result, the food structure was suddenly expanded and created the porous structure. This phenomenon provided high crispness and low hardness texture [6, 7]. Nowadays, puffing technique was successfully applied in many kinds of fruit and vegetable such as potato, apple, and banana [1 – 3, 7 – 9]. Tabtiang *et al.* [4] studied the effects of ripening level and puffing temperature on quality of puffed Numwa-banana slices. The result indicated that the ripening level and puffing temperature significantly affected the drying time and product quality. Meanwhile, high puffing temperature and ripening level provided high volume expansion and colour change, but gave low hardness. However, the sensory evaluation of puffed banana was not investigated and compared with commercial product.

Thus, the objective of this work was to study the effects of ripening level and puffing temperature on the drying time and qualities of puffed Homtong-banana slices. The qualities of puffed product were evaluated in terms of colour, volume ratio and texture. In addition, the sensory evaluation was determined.

2. Materials and methods

Raw materials

Fresh Homtong-banana were purchased from a local farm. The ripening level of banana of this experiment was divided in three levels: 16 – 18, 20 – 22, and 24 – 26 °Brix. Bananas were peeled and sliced with cross sectional into 2.50 mm thickness. They were pretreated by hot water at 95 ºC for 30 s. The initial and final moisture content of the samples were analysed by AOAC method [10].

Puffing process

The puffing process contained three drying steps. First of all, the banana slices were dried at 90 ºC, air velocity of 2 ms^{-1} until the moisture content reached to 40% d.b. Next, the samples were puffed at a temperature of 130, 150 and 170 ºC for 2 min. Finally, those puffed samples were dried again at a temperature of 90 ºC to the final moisture content of 4% d.b.

Determinations of glucose, fructose and sucrose content

The sugar content in fresh banana was performed according to AOAC method 982.14 [10]. 5 g of sample were crushed and mixed with 50 mL distilled water. Then, 1.25 mL of 15% $K_4(Fe(CN_6)).3H_2O$ and 1.25 mL of 30% $ZnSO_4.7H_2O$ were added into the solution in order to extract the protein from sample. The sample solution was adjusted to 100 mL by distilled water and filtered through No. 1 filter paper. Then, the supernatant was filtered again through 0.20 µm syringe filter. The filtered sample solution was kept in refrigerator until the next experiment. Then sugar content was analyzed by High Performance Liquid Chromatography (HPLC). 10 µL of the filtered solution were injected into HPLC. Fructose, sucrose and glucose content of sample could be separated by isocratic separation. Peak areas of samples were quantified with a standard curve of each sugar.

Determinations of starch content

A 5 g of fresh sample were mashed and mixed with 50 mL distilled water. Then, the solution was filtered through No. 1 filter paper and the precipitate was cleaned by distilled water. The cleaned precipitate was adjusted volume to 200 mL by distilled water and 20 mL of 25% HCl solution was added in the solution. Next, it was heated by Reflux condenser for 2.50 h and immediately cooled down at the room temperature. Then, pH of this solution was adjusted to neutral by using 20% NaOH solution and then the neutralized solution was adjusted to 250 mL by distilled water. Glucose content was determined by Somogyi [11] and starch content was calculated by following equation (1):

$$\text{Starch content} = \text{Glucose content} \times 0.925 \quad (1)$$

Determinations of pectin content

The pectin content in fresh banana was determined by AOAC method [10]. A 5 g of sample were mashed and mixed with 100 mL distilled water. The pH of solution was adjusted to range of 2 – 3 by using 10% HNO_3 solution and then it was heated at 80 ºC for 2 h. The supernatant of cooled solution was separated by using centrifugal technique at 2700x for 15 min. Then, the pH of this solution was adjusted to 4.50 by using 1 M NaOH solution. The solution was concentrated by rotary evaporator for 2 h. After that, 95% ethanol was added to the concentrated solution in the ratio of 4:1 (ethanol:sample solution). The solution was left for 12 h in order to completely separated pectin. The precipitated pectin was separated by centrifugation at 2700x for 15 min again and it was dehydrated at 60 ºC for 5 h.

Colour measurement

The colour of puffed sample slices were measured by a colourimeter (model ColorFlex, HunterLab Reston, VA, USA) with a D65 illuminate and 10° view angle. The colour of puffed samples was expressed in terms of L (lightness/darkness), a (redness/greenness) and b (yellowness/blueness) values. Before measuring the colour of puffed sample, the colourimeter was calibrated with standard black and white plates. Twenty banana sample were measured and the average value was calculated. The colour values of puffed sample were presented in term of the total colour change (ΔE) which can be calculated by the following equation (2):

$$\Delta E = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \quad (2)$$

Where L_0 is the brightness of fresh sample, L is the brightness of dried sample, a_0 is the redness of fresh sample, a is the redness of dried sample, b_0 is the yellowness of fresh sample and b is the yellowness of dried sample.

Volume ratio measurement

The volume change of the dried sample was determined by the volume ratio measurement. The volume ratio of puffed banana sample were calculated as equation (3):

$$\%\ \text{Volumetric expansion} = \frac{V}{V_i} \times 100 \quad (3)$$

Where V_i is the volume of the initial fresh sample and V is the volume of dried sample.

The volumes of initial and dried sample were determined by a solid replacement method with glass breads. The solid replacement method was described by Tabtiang *et al.* [3, 4]. The volume of banana slices were calculated by following equation (4):

$$V = \frac{M_b - [M_{s+b} - M_v - M_s]}{\rho_b} \quad (4)$$

Where M_b is the mass of container filled with glass breads, M_v is mass of empty container, M_{s+b} is mass of container plus glass breads and banana sample, M_s is the mass of sample and ρ_b is the density of glass breads.

Texture measurement

The textural property of product was evaluated by texture analyzer (TA-XT2i, Stable Micro Systems Texture, UK). For this study, the sample was measured in term of hardness and the number of peaks. The hardness value of puffed samples is a maximum force from the force deformation curve. The number of peaks were counts as the peaks higher than the threshold value, which was set at 30 g.

Force test was performed with a cutting probe (HDP-BSK) at test speed of 2 m s^{-1}. Average hardness value of twenty banana slices were recorded.

Sensory evaluation

The puffed banana from experiment with large volume ratio, low values of hardness and ΔE was selected for sensory evaluation using a nine-point hedonic scale. Sensory evaluation of puffed sample was considered in terms of appearance, colour, texture and overall preference. Each category was rate from 1 (dislike very much) to 9 (like very much) to evaluate the statistical significance of sensory test. The fifty panelists from King Mongkut's University of Technology North Bangkok were assessors to evaluate the sample scores. The commercial fried banana chips were used for comparison.

Statistical analysis

The data of product quality in terms of colour, volume expansion, and hardness value were analyzed by the Analysis of Variance by using SPSS software Version 21 (IBM Crop., Armonk, NY, USA). Differences mean values were established using Tukey's Multi Range Tests at a confidence level of 95% ($p<0.05$).

3. Results and discussion

Chemical composition of banana at different ripening levels

The chemical composite of fresh banana are determined in terms of starch, sugar content (fructose and glucose), and pectin. The chemical compositions of fresh Homthong banana at different ripening levels are shown in Table 1. The results showed that the ripening level of banana effected to the amount of chemical composite in fresh banana. The 16 – 18 ºBrix banana contains the highest amount of starch and pectin in tissue. Since the amount of both of polymers tend to decrease as the ripening was developed. However, the amount of monosaccharide increased as higher ripening level. This is because some amount of starch degrades to monosaccharide [12].

Table 1 Starch, fructose, glucose and pectin contents of Homthong-banana at different ripening levels.

Ripening level (ºBrix)	**Starch** (g g^{-1} dry mass)	**Fructose** (g g^{-1} dry mass)	**Glucose** (g g^{-1} dry mass)	**Pectin** (g g^{-1} dry mass)
16 – 18	0.36 ± 0.03	0.05 ± 0.01	0.05 ± 0.01	0.20 ± 0.04
20 – 22	0.17± 0.02	0.13 ± 0.02	0.13 ± 0.02	0.17 ± 0.03
24 – 26	0.09 ± 0.01	0.15 ± 0.03	0.14 ± 0.02	0.09 ± 0.02

Colour

The colour quality is presented in term of ΔE. The puffed banana colour had more browning as indicated by higher ΔE value [4]. Figure 1 shows the colour change (ΔE) of puffed Homthong-banana slices at different experimental conditions. It can be seen that the ripening level and puffing temperature significantly affected on the colour of puffed banana slices. The puffed banana had less brown colour as lowest level of banana ripening and browning was developed as higher level of ripening. This is due to higher amount of monosaccharide as higher ripening level accelerated more non-enzymatic brown reaction [3, 13]. In case of puffing temperature, higher level of puffing temperature promoted browner colour of puffed product. It could be explained by the fact that higher puffing temperature could be promoted non-enzymatic browning reaction on banana sample [4]. In addition, the puffed samples had more scorching at banana surface as higher level of ripening stage and highest puffing temperature. Therefore, the puffed sample obtained from highest level of both factors may be risk on consumer health.

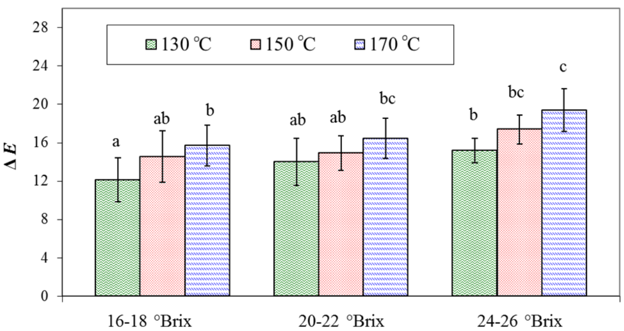

Fig. 1 Effect of ripening level and puffing temperature on the ΔE value of puffed Homthong-banana.

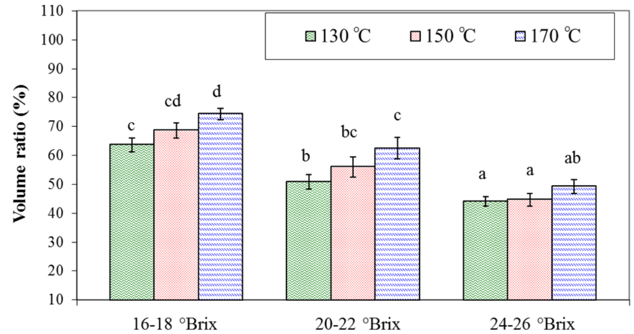

Fig. 2 Effect of ripening level and puffing temperature on volume ratio of puffed Homthong-banana.

Volume ratio

Fig. 2 shows the effects of ripening level and puffing temperature on volume expansion of puffed Homthong-banana slices. It was found that lower ripening level resulted in a higher volume ratio of puffed product. This is because the higher starch content in sample at the lowest ripening level, as shown in Table 1, could be generate completed seal surface lager that escape vapor during puffing step [7]. Moreover, higher puffing temperature promoted larger volume ratio of puffed banana. This could be explained that higher puffed temperature provided higher product temperature and then leading to higher moisture evaporation rate. These higher vapor potentially forces the volume to larger expansion [5-7]. However, the puffing temperature insignificantly affected on volume ratio of puffed sample as the highest ripening level. It may be due to highest amount of monosaccharide at this ripening stage obstructed completed sealed surface layer from starch gelatinization. Therefore, the vapor that generated during puffing easy leaked out from inside to outside banana sample.

Texture

Texture of puffed banana product was presented in term of hardness and the number of peaks. Fig. 3 (a) shows the effects of ripening level and puffing temperature on hardness of puffed banana slices. Lower hardness value of puffed banana slices obtained from higher puffing temperature. This is the fact that higher volume expansion of puffed sample resulted in more porosity inside its structure, these evident was supported from Fig. 3 (b). The higher porosity that obtained from larger puffed volume provided lower hardness of puffed sample. In case of ripening level, the highest hard texture was observed at 16 – 18 ºBrix of banana and its texture tends to decrease as higher ripening level. The 16 – 18 ºBrix of ripening stage provided highest hardness because it had highest amount of pectin as shown in Table 1. Pectin is polymer component of middle lamella and it can bind cell together [14]. Therefore, high amount of pectin in cellular provide stronger cellular structure of banana.

Fig. 3 (c) showed the effect of ripening levels and puffed temperature on the number of peaks. The highest value of the number of peaks was observed at 16 – 18 ºBrix of ripening level. It could be because 16 – 18 ºBrix banana had the highest volume ratio then its structure contained more porosity as shown in Fig. 3 (b). However, the number of peaks significantly decreased as higher level of ripeness. In case of puffing temperature, the puffed sample had higher the number of peaks as higher puffing temperature level. This is related with the higher volume of puffed banana that obtained from higher puffing temperature had more porosity inside its structuure. However, the puffing temperature insignificantly affected on the number of peaks as 24 – 26 ºBrix of ripening level.

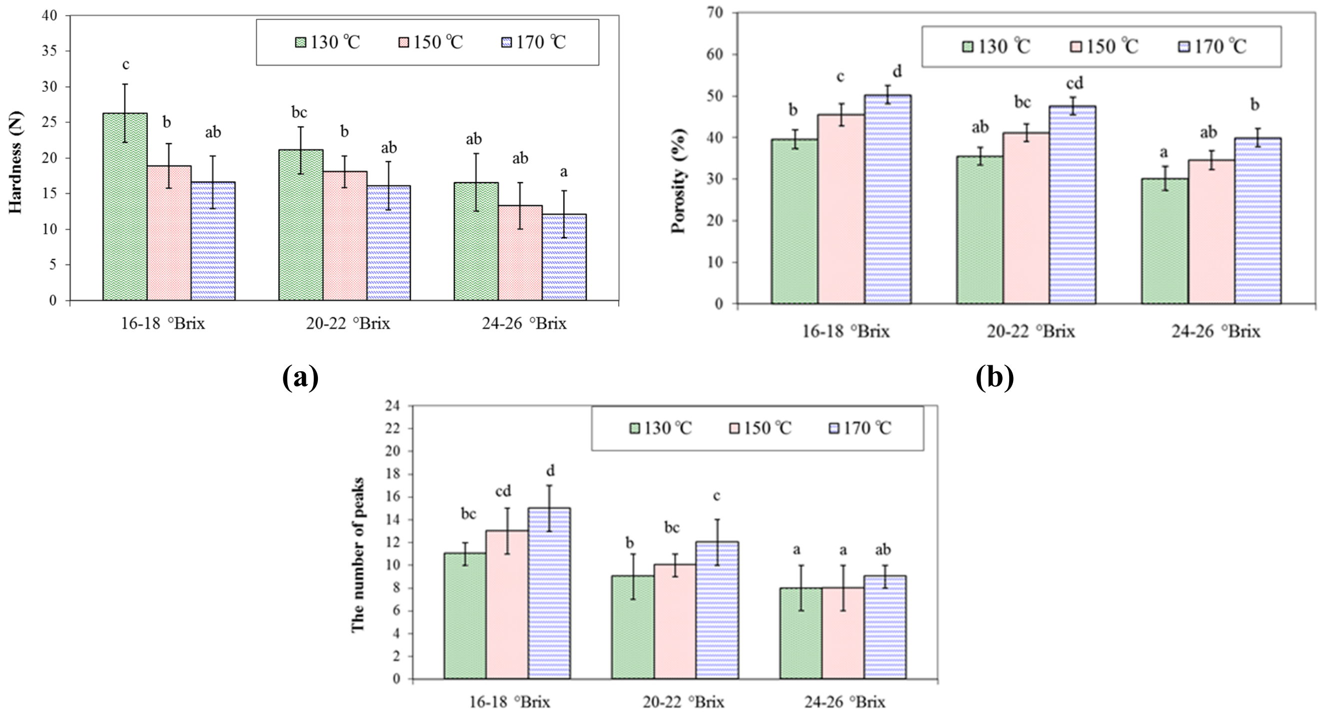

Fig. 3 Effect of ripening level and puffing temperature on hardness (a), porosity (b) and the number of peaks (c) of puffed Homthong-banana.

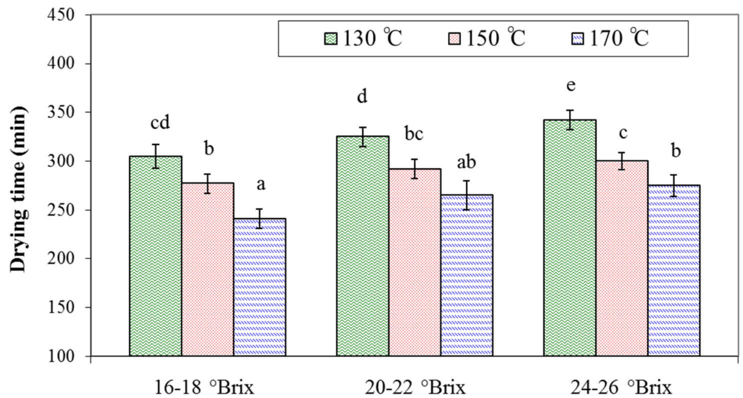

Fig. 4 Effects of ripening level and puffing temperature on drying time of puffed Homthong- banana.

Table 2: Sensory evaluation of puffed banana slices obtained from the experiment and commercial fried banana.

Sample	Colour	Appearance	Hardness	Crispness	Overall preference
Puffed banana	5.22 ± 0.5^{a}	6.53 ± 1.1^{a}	5.13 ± 0.7^{a}	5.24 ± 0.6^{a}	5.63 ± 0.4^{a}
Commercial fried banana	6.67 ± 0.7^{b}	5.39 ± 0.9^{a}	7.58 ± 0.5^{b}	7.21 ± 0.5^{b}	6.81 ± 0.4^{b}

The different latters in same column of table show significant difference (p<0.05).

Drying time

The drying time of Homthong-banana slice at different ripening level and puffing temperature is shown in Fig. 4. It can be seen that the lower ripening level showed a shorter drying time. This is related to the higher volume ratio as lower ripening level contained higher porosity inside puffed structure.

Such its structure could be facilitates moisture movement inside to banana surface with faster rate. In other reasons, higher amount of monosaccharide as higher ripening level bonds with moisture and then moisture difficult remove from the banana tissue [2]. In addition, higher puffing temperature provided shorter drying time of drying process. Higher puffing temperature could be reduce drying time because higher puffing temperature promoted higher evaporation rate of moisture inside sample. Therefore, shorter drying time at final processing stage was required. Moreover, it was found that all cases of puffed products were the final moisture content of 4% d.b.

Sensory evaluation

In sensory evaluation, the puffed banana sample obtained from experiment was selected at 150 °C of puffing temperature and 16-17 °Brix of ripeness degree was chosen to compare with commercial product. Table 2 shows the sensory evaluation results of the puffed banana and commercial fried banana product. The commercial fried banana had significantly higher score in terms of colour, hardness, crispness and overall preference than puffed banana obtained from experiment. However, the appearance score of both samples were not significantly different.

4. Conclusion

The results indicated that high fructose and glucose contents and low starch-pectin contents were found in high ripening level of banana. The ripening level and puffing temperature strongly affected the drying time and qualities of puffed banana slices. Higher ripening level of banana provided lower volume ratio and lower hardness, but gave high ΔE or browner colour of puffed banana. Meanwhile, higher puffing temperature gave higher volume expansion and more brown colour but lower hardness. The drying time of puffed banana slices decreased as higher puffing temperature and lower ripening level. In addition, optimal condition for producing crispy banana was recommended at 150 °C and 16 – 18 °Brix. In comparison with commercial product, the puffed product was less preferred in terms of colour, hardness, crispness and overall preference.

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