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EFFECTS OF PROCESS PARAMETERS ON PUFFED BANANASNACK QUALITY

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ABSTRACT

The healthy snacks become increasingly popular. The low-fat crispy snack, puffed banana slices, is one of alternative products for health conscious consumer. The crisp texture of snacks is important to consumer's acceptability. Crispness is associated with porous structure of foods. To obtain porous structure of banana, puffing technique is an alternative method to produce this snack. In this study, the effects of blanching, thickness, ripe stage and puffing temperatures on qualities of puffed banana slices, i.e. color, degree of shrinkage and textural properties were investigated. The experimental results showed that the blanching, ripe stage, puffing temperature and thickness affected the shrinkage. All process parameters, except the puffing temperature, also influenced textural property as characterized by hardness and crispiness. The blanching can improve the appearance and color but it caused the harder texture since the cellular structure was collapsed during blanching step. To prevent the brown color development or scorching, it recommended puffing banana at temperature below 180°C.

INTRODUCTION

Nowadays, the trend of oil-free crispy snack product is more interested in health conscious consumer. The quality attributes of snacks would have a desirable appearance, texture, taste and color. Among these, texture and color are important quality attributes. Crispness is considered through a combination of tactile, kinesthetic, visual and auditory which represent the texture attributes of snack products. Crispness is also associated with rapid drop of force during mastication process that it is based on fracture propagation in brittle materials [1].

To produce the healthy snacks, puffing technique is an alternative method. By this technique, the moisture existing inside the food rapidly evaporates in a very short period and this would generate vapor pressure inside the food, thus yielding higher pressure and the corresponding expansion of product volume [2]. Many factors of puffing process affecting the puffed product qualities such as volume expansion, texture and color are the initial moisture content, puffing temperature, puffing time, blanching and thickness [3-5].

Blanching sample before process can increase the plasticity of sample and reduce permeability of water vapor. This provides a high expansion of product during puffing [4]. In addition, blanching, the thickness of product may affect degree of volume expansion. Rakesh and Datta [6] reported that the decrease in thickness of the sample let to faster removal of moisture from the surface and this causes a small expansion of product volume. In addition, the stage of ripening is important to technical aspect of processing. Banana slices prepared by at different stages of ripening might affect textural property and quality attribute of product such as shrinkage, crispness and color.

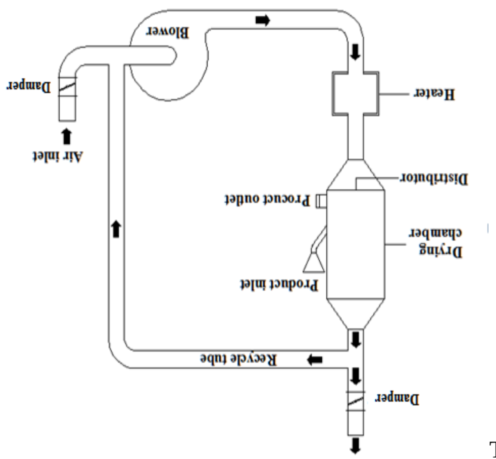
As above mentioned, this study was aimed to investigate the effect of ripening stage and process parameters on quality of banana chips in terms of color, degree of shrinkage and texture.

MATERIALS AND METHODS

Materials

Gros Michel bananas (*Musa Sapientum* L.) purchased from a local market contained total soluble solids contents in a range of 17 to 18°Brix and 3 to 5°Brix. Before processing, the bananas were peeled and sliced into 2.5 and 3.5 mm-thick using a cutting machine (Savioli, model no 250S, Thailand). The banana slices were pretreated by citric acid at concentration of 1 % w/v for 2.5 mm thickness and 3 % w/v for 3.5 mm thickness for 5 minutes. After that, the samples were blanched in hot water at 90 °C for 1 min.

Puffing process



The puffing process was consisted of three main steps. The fresh sliced bananas were pre-dried in a tray dryer at the drying temperature of 90 °C and the superficial velocity of 2 m/s from its initial moisture content to the intermediate moisture contents of 25 % (d.b.). After that, the samples were puffed in a hot air fluidized bed dryer, as shown in Fig, 1, by using temperatures of 160 and 180 °C and a superficial velocity of 3.5 m/s. Finally, they were further dried in the tray dryer with the same drying condition of the first step to reduce the moisture content to 4 % (d.b.). The fluidized-bed dryer used for the puffing process consists of three major components: a cylindrical drying chamber with an inner diameter of 20 cm and a height of 140 cm, 12-kW electrical heaters with a temperature controller, and a backward curved-blade centrifugal fan driven by a 1.5 kW motor. A 30 g sample was puffed in a fluidized bed dryer. Only 30 gram of the banana sample can be used in the puffing process to ensure the occurrence of fluidization.

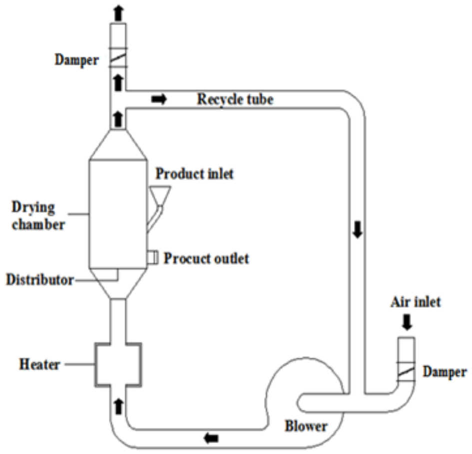


Fig. 1 Schematic diagram of hot air fluidized-bed dryer

Measurement of moisture content

A 3-5 g sample was mashed and dried for determining its moisture content. The moisture content of fruits is traditionally determined by the standard vacuum oven method 934.06 (AOAC, 1995) [7]. In this work, however, the moisture content of banana slices was measured by drying them at temperature of 103 °C for 3 h in a hot air oven (Memmert, model no,ULE500, Schwabach, Germany). The moisture content measured by this method was closed to that obtained by the vacuum oven method with differences of approximately 0.4-0.6%.

Quality evaluation

Shrinkage measurement

Ten samples obtained from each experimental condition were used to determine their shrinkage. The shrinkage of each sample was determined by solid displacement method using glass beads with diameter in a range of 0.106-0.012 mm [8]. The percentage of shrinkage was calculated by Eq. (1).

$$\%\ \text{shrinkage} = \left(\frac{V_0 - V}{V_0}\right) \times 100 \qquad (1)$$

where V_0 is the volume of fresh banana slice and V is the volume of dried banana slice.

For each measurement, one sample piece was used and the average value of ten samples was reported. The samples were weighed and transferred to an aluminum can and glass beads were poured over the banana sample until the aluminum can was full. The volume of banana sample (V) was calculated using Eq. (2).

$$V = \frac{M_b - [M_{S+b} - M_v - M_S]}{\rho_b} \qquad (2)$$

where M_b is the mass of the aluminium can filled with beads, M_v is the mass of the empty can, M_{S+b} is the mass of can plus the sample and the beads, M_s is the mass of sample and ρ_b is the bulk density of the glass beads.

Color measurement

The color of the puffed banana slices was measured at its surface by colorimeter (ColorFlex, HunterLab, Buckinghamshire, UK) with D65 illuminant and view angle of 10°. The colorimeter was calibrated with the standard white and black plates before testing the sample. For each banana slice, five different positions around the banana surface were measured and the average value of ten samples was used to represent their color. The mean values of L (brightness/darkness), a (redness/greenness) and b (yellowness/blueness) were reported.

Texture measurement

Fifteen samples were used to determine textural property. Hardness and crispiness properties of dried samples were measured by a texture analyzer (TA. XT. Plus, Stable Micro System, Haslemere, UK), which was equipped with a cutting probe (HDP-BSK type; Instron Ltd., High Wycombe, UK) connected to a 5 N load cell. The cutting probe was set to travel at a crosshead speed of 2 mm/s. The maximum force was considered as hardness in the force deformation curve while the crispness of banana slices was characterized by a number of peaks and an initial slope of the first peak. The number of peak was counted when the peak had a value higher than the threshold value of 30 g.

Statistical analysis

All experimental data were subjected to the analysis of variance (ANOVA) using SPSS® and is presented as mean values with standard deviations. Turkey's test was used to evaluate the multiple comparisons of the mean values. Mean values were considered significantly different at p>0.05.

RESULTS AND DISCUSSION

Shrinkage

Table 1 shows the effect of blanching, ripening stage, thickness and puffing temperature on the degree of shrinkage of banana slices. When the ripe stage 1 and 3 bananas for 2.5 mm thickness were blanched, the samples had the degree of shrinkage insignificantly. However, the shrinkage of blanched sample was significantly higher than that of the unblanched sample for all puffing temperatures. The larger shrinkage can be explained that the gelatinization of starch might affect the cell structure and increase the internal resistance, resulting in rigid structure during the drying in the first stage. Hence, the expansion of the sample during puffing is difficult and subsequently results in higher shrinkage.

Considering the thickness of sample between 3.5 mm and 2.5 mm for the ripe stage 3 banana, the shrinkage of banana sample in the case of 3.5 mm thickness was lower than that in the 2.5 mm thickness. This is because the decrease in thickness of the sample leads to a shorter distance of moisture travelling from the interior locations to reach the surface. Hence, when moisture is evaporated, it lost rapidly before pressure develops, resulting in insufficient moisture insufficient inside the 2.5 mm thickness sample to be expanded. Moreover, when using the higher puffing temperature could not reduce the shrinkage; the degree of shrinkage of banana samples puffed at 160 and 180°C was insignificantly different. However, using higher puffing temperature can be achieved when applied to the banana sample with 3.5 mm thickness; the shrinkage of sample puffed at 180°C was significantly lower than that at 160°C. From Table 1, it can also be seen that the ripening stage did not affect the shrinkage; the degree of banana shrinkage obtained from stage 1 and 3 was almost identical.

Table 1 Effects of blanching, ripe stage, thickness and puffing temperature on shrinkage of banana slices

Thickness (mm)	Puffing Temperature (°C)	Degree of Shrinkage (%)
1-min blanching for Stage 3 : (17-18 oBrix)		
3.5	160	61.7±1.9g
3.5	180	53.9±1.6f
2.5	160	40.8±1.6e
2.5	180	39.7±1.4e
Unblanching for Stage 3 : (17-18 °Brix)		
3.5	160	6.1±1.6b
3.5	180	2.6±1.7a
2.5	160	27.2±1.5c
2.5	180	26.8±1.4c
1-min blanching for Stage 1 : (3-5 oBrix)		
2.5	160	39.7±1.8e
2.5	180	36.9±1.9d

Remark: Different superscripts in table indicate a significant difference at (p<0.05).

Textural properties

Table 2 shows the effects of blanching, thickness, ripening stage and puffing temperature on textural properties of banana slices in terms of hardness, initial slope and number of peaks. It was found that the blanched samples in the case of 3.5 mm thickness had higher value of hardness and smaller number of peaks than those textural properties of unblanched sample whereas the initial slope was insignificantly different. The higher hardness might be due to the fact that the starch gelatinization was taken place and this let to the cell structure collapsed, resulting in small expansion of banana during puffing step.

In the case of ripening stage 1 and 3 for blanched banana at 2.5 mm thickness, the ripe stage 1 banana had higher hardness than that of ripe stage 3. This was because the soluble solids content increase from early stage until the end of maturity resulting in firmness decreased. Hence, the texture of ripe stage 3 had less hardness than that of ripe stage 1 banana.

The decrease of thickness can improve the harness; the hardness of banana sample was significantly lower in 3.5 mm thickness than in 2.5 mm thickness. On the other hand, the crisp texture as characterized by initial slope and number of peaks was improved; it was less crispy for 2.5 mm thickness. It is interesting to note that the texture properties were not different for the 2.5 mm thickness with blanching or unblanching although the degree of shrinkage of both cases was different. Using puffing temperature between 160 and 180°C did not affect the textural properties for all study cases.

Table 2 Effects of blanching, ripe stage, thickness and puffing temperature on textural properties of banana slices

Thickness (mm)	Puffing Temperature (°C)	Initial Slope (N/mm)	Hardness (N)	Number of Peaks
1-min blanching for Stage 3 : (17-18 °Brix)				
3.5	160	33.4±3.3^{cde}	31.0±4.6^{e}	13±5^{b}
3.5	180	37.1±5.7^{de}	27.1±5.7^{de}	14±5^{b}
2.5	160	22.5±5.4^{a}	10.8±3.8^{a}	3±2^{a}
2.5	180	23.0±2.9^{a}	9.1±3.3^{a}	4±3^{a}
Unblanching for Stage 3 : (17-18 °Brix)				
3.5	160	31.8±5.8^{cd}	18.3±3.6^{bc}	20±5^{c}
3.5	180	37.8±5.8^{e}	17.2±4.8^{b}	21±4^{c}
2.5	160	22.3±6.1^{a}	11.1±2.9^{a}	4±2^{a}
2.5	180	24.8±5.1^{ab}	9.9±2.6^{a}	5±3^{a}
1-min blanching for Stage 1 : (3-5 °Brix)				
2.5	160	29.9±4.3^{bc}	22.6±3.9^{cd}	10±3^{b}
2.5	180	32.9±3.9^{cde}	19.9±3.8^{bc}	12±3^{b}

Remark: Different superscripts in table indicatea significant difference at (p<0.05).

Color

The surface color of dried banana slices as affected by the puffing temperature, thickness, blanching and ripening stage of banana is illustrated in Table 3. Since the change of color parameters during puffing relates to browning reactions, the color parameters are decreased in L-value and b-value, and increased in a-value.

Table 3 Effects of blanching, ripe stage, thickness and puffing temperature on banana surface color

Thickness (mm)	Puffing Temperature (°C)	L-value	a-value	b-value
1-min blanching for Stage 3 : (17-18 °Brix)				
3.5	160	34.12±0.75^{cd}	6.07±0.67^{cd}	12.79±0.48^{abc}
3.5	180	32.71±0.61^{ab}	9.36±0.27^{g}	13.27±0.59^{abcd}
2.5	160	33.88±0.79^{bcd}	5.14±0.44^{c}	12.14±0.71^{a}
2.5	180	33.07±0.63^{abc}	8.02±0.45^{f}	12.49±0.23^{ab}
Unblanching for Stage 3 : (17-18 °Brix)				
3.5	160	42.96±0.83^{f}	6.78±0.82^{de}	16.22±0.51^{g}
3.5	180	31.76±0.58^{a}	8.84±0.63^{fg}	15.63±0.72^{fg}
2.5	160	37.67±0.53^{e}	7.83±0.51^{ef}	13.95±0.40^{de}
2.5	180	34.66±0.53^{d}	8.08±0.57^{f}	13.43±0.40^{bcd}
1-min blanching for Stage 1 : (3-5 °Brix)				
2.5	160	43.18±0.60^{f}	1.59±0.20^{a}	13.82±0.64^{cde}
2.5	180	42.23±0.45^{f}	3.27±0.39^{b}	14.89±0.43^{ef}

Remark: Different superscripts in table indicate a significant difference at (p<0.05).

When the banana sample with ripe stage 3 was puffed at 160°C, the unblanched product had creamy white but it had the golden yellow for the blanched sample, which was similar to the color of fried product. It had no scorching at the banana surface. However, when it was puffed at 180°C, the samples were relatively brown in both blanched and unblanched samples, which are quantitatively interpreted by *L* value of 32.71 and 31.76 for blanched and unblanched, respectively. This was due to the fact that this puffing temperature increases the product temperature, which accelerates the non-enzymatic browning reactions [3, 9]. However, with the ripe stage 1 banana, the drying temperature did not affect the color and the sample had white pearl.

CONCLUSIONS

The effects of puffing temperature, thickness, ripening stage, blanching on quality of puffed banana slices in terms of color, texture property and degree of shrinkage were investigated. The experimental results showed that high puffing temperature caused the lower shrinkage for both blanched and unblanched samples which affected only the sample size of 3.5 mm thickness. However, it had no effect on textural properties. The blanched sample for ripe stage 3 in all thickness had higher degree of shrinkage than the unblanching case which provided subsequently more hardness and less crispiness. Difference of ripening stage for blanched banana in the case of 2.5 mm thickness did not affect the degree of shrinkage. However, the ripening stage 1 banana had the textural in terms of hardness higher than ripening stage 3. The color of blanched banana in the case of ripe stage 3 for all thickness at puffing temperature of 160 °C had golden yellow while the unblanched sample had creamy white. However, the bananas puffed at 180°C were relatively brown in both blanched and unblanched sample. To achieve the less brown color, the banana should be puffed at puffing temperature of 160°C. The blanching step can improve the appearance, but the textural attribute of product had more hardness and less crispness than unblanched sample.

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