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Effect of Pre-treatment on Quality of Cassava Chips

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Abstract

This research was to look at cassava root as an alternative raw material for snack chip production. However, cassava chips showed higher hardness compared to potato chips. The aim was to study the effect of pre-treatment on the physical, chemical and sensorial characteristics of cassava chips. Fresh cassava slices (1 mm thickness) were soaked in sodium bicarbonate ($NaHCO_3$) solution at different concentrations (un-soaked, 0, 1 and 2% w/w) for 5 min. Then, cassava slices were fried in palm oil at 160ºC for 4 min and were seasoned with paprika powder before being baked at 180ºC for 10 min. The chemical, physical and sensorial qualities were investigated. The results revealed that the bulk density of cassava chips decreased significantly from 0.496 to 0.401 g/cm^3 when fresh cassava slices were soaked in 2% $NaHCO_3$. The breaking force of cassava chips also decreased from 558.97 to 231.50 g whereas fat content increased from 22.85 to 30.69% when soaked in 2% $NaHCO_3$. Increasing the concentration of $NaHCO_3$ decreased the lightness (L^*) of cassava chips. Pre-treatment did not have a significant effect on the sensory scores of cassava chips.

Keywords : Cassava Chips; Pre-treatment; Frying; Quality

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1. Introduction

Thailand's snack market was 36 billion baht in 2018 and its growing rate within the snack market was 6% [1]. The five main segments of snacks in Thailand include extruded snacks (35%), potato chips (30%), prawn crackers (10%), dry peas and nuts (10%) and others (15%). Potato chips were the fastest growing segment of all [1], [2]. Mazurek et al. [3] also reported that the most popular chip products were potato chips.

Cassava (*Manihot esculenta*) is the third largest source of food carbohydrates for humans [4] and it is one of Thailand's most important economic crops. Thailand was the world's largest cassava exporter with a production of 33 million tons in 2016, which is 67% of the global market [5]. Cassava roots are very rich in starch and contain small amounts of calcium, phosphorus and vitamin C [6]. In 2017, Thailand produced 107,103 tons of fresh potatoes whereas demand for fresh potato as a raw material for producing potato-based products was about 150,000 tons [7]. As a result, Thailand has been imported potatoes from China, Canada and Germany for use in its food industry.

Moreover, the price per kilogram of cassava root is much cheaper than potatoes; namely about 10 times cheaper. The aim of this research was to look at cassava root as an alternative raw material for the production of snack chips. However, the cassava chips showed a higher hardness value when compared with potato chips. Therefore, the objective was to study the effect of pre-treatment on the qualities of cassava chips. The pre-treatment methods consisted of soaking in water and sodium bicarbonate ($NaHCO_3$) solutions. $NaHCO_3$ increased the volume expansion of extruded black beans [8] and enhanced the texture, density and expansion ratio of puffed corn-fish snack [9]. There were a few prior studies on the effects of processing cassava chips [10], [11], and there were several previous research studies which looked at the effects of processing potato chips [12] – [17], banana [18], carrot [19] and cereal products [20].

2. Materials and Methods

2.1 Materials

Fresh cassava roots, palm oil (Morakot, Thailand) and seasoning powder (i-chef, Thailand) were purchased from a local market in Surat Thani Province, Thailand. Fresh cassava roots were kept at 4°C prior to processing.

2.2 Pre-treatments for Producing Cassava Chips

Cassava roots were peeled and then washed with tap water. Further, cassava roots were sliced to a thickness of 1 mm. These slices were soaked in sodium bicarbonate ($NaHCO_3$) solution at various concentrations (0, 1 and 2% w/w) for 5 min. The ratio of cassava to $NaHCO_3$ solution was 1:3. The excess water was wiped away with a clean cloth. The pre-treatment cassava slices were fried in palm oil at 160°C for 4 min with the cassava to palm ratio being 1:10. Then, cassava chips were seasoned with paprika powder (the ratio of cassava chips to paprika powder was 100:2) and baked at 180°C for 10 min in an oven. Finally, the cassava chips were cooled and kept in a plastic bag until their quality analysis. The detailed protocol employed for producing cassava chips is shown in **Fig. 1**.

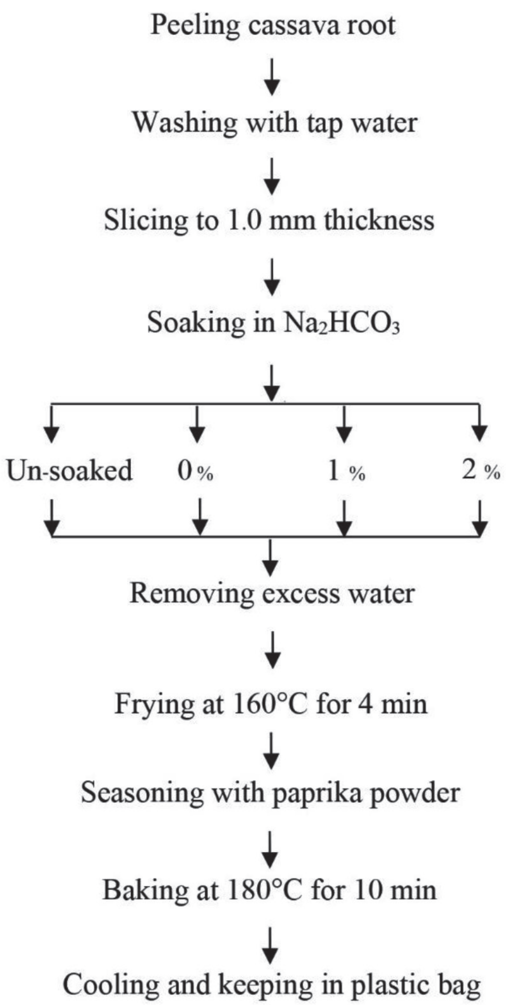

Fig. 1 Flow chart indicating the protocol involved in producing cassava chips

2.3 Chemical Analysis

Moisture content: The moisture content of cassava chips was measured following the method of AOAC [21]. Briefly, ground samples (3 g) were dried to a constant weight in a hot air oven (Redline, Binder, German) at 105°C. The moisture content was calculated from the weight difference between the original and dried samples.

Fat content: The total fat content of the cassava chips was extracted with petroleum ether for 4 h in a Soxtec auto extraction unit (2050 Soxtec Tecator, Denmark) and gravimetrically determined.

2.4 Physical Analysis

Bulk density: The bulk density of the cassava chips was calculated by dividing the weight (g) by the volume of the samples (cm^3).

Water activity (a_w): Ground samples were placed in a cup and water activity (a_w) was measured by using a water activity meter (CH-8303, Rotronic, Switzerland).

Color measurement: The color of the samples was measured in the L^*, a^* and b^* mode of CIE (angle 10°, illuminant D65) by using a color meter (CR-400, Konica Minolta, Japan).

Texture measurement: A texture analyzer (CT3, Brookfield, Germany) was used to determine the breaking force of cassava chips. The samples were placed on a modified TA-TPB fixture and a knife edge (60 mm width) probe, moving at a speed of 0.5 mm/s over a distance of 10 mm, was used to break the cassava chips. The breaking force was expressed in grams-force.

2.5 Sensory Analysis

The 9-point hedonic scale was used to evaluate the acceptability of the cassava chips. Fifty untrained panelists made up of students at Surat Thani Rajabhat University were asked to rate their liking of quality attributes including appearance, flavor, crispness, taste and overall liking of each sample (1 = dislike extremely, 5 = neither dislike nor like and 9 = like extremely).

2.6 Statistical Analysis

The experiments were conducted in triplicate. The results were reported as mean values with standard deviations. Analysis of variance (ANOVA) and Duncan's New Multiple's Range Test (DMRT) were used to determine statistically significant differences of treatment parameters ($p < 0.05$) using the SPSS V.21 statistical software package.

3. Results and Discussion

3.1 Chemical Qualities

The effect of pre-treatment on moisture content and water activity (a_w) of cassava chips are shown in **Table 1**. Fresh cassava slices were soaked in sodium bicarbonate ($NaHCO_3$) solution at various concentrations (0, 1 and 2% w/w) for 5 min. The pre-treatment cassava slices were fried in palm oil at 160°C for 4 min and baked at 180°C for 10 min. The concentration of $NaHCO_3$ solution used did not exceed 2% because it would have affected the taste of the cassava chips. The results revealed that moisture content in cassava chips are significantly different ($p<0.05$) with soaking fresh cassava slices in 2% $NaHCO_3$ solution. The moisture content of cassava chips ranged from 0.96 – 1.42%.

The total fat contents of cassava chips as affected by the pre-treatment method are shown in **Table 1**. The results showed that soaking fresh cassava slices in a higher concentration of $NaHCO_3$ resulted in higher fat content. The total fat content in cassava chips increased from 22.85% to 30.69% (Wet Basis) when increasing the concentration of $NaHCO_3$ to 2%. Normally, the mean oil contents of potato chips and tortilla chips are 37.5 and 23.4 g/100 g sample, respectively [22]. Mazurek et al. [3] also reported that commercial chips with a fat level reaching 30 – 40% dominate the market. The key factors affecting oil absorption in fried products include the frying process, product characteristics and oil quality [23]. Soaking cassava slices in water and

$NaHCO_3$ solution prior to frying increases fat content in cassava chips due to surface wetting [24]. Higher initial moisture content leads to an increase in oil uptake in cassava chips, similar to that found in tortilla chips [25]. Oil replaces the water that has evaporated during the frying process. The water-replacement mechanism is described as follows. When the food is exposed to frying temperatures, water evaporates rapidly, the outer surface becomes dry and crust forms. Moisture within the fried product is converted to steam, creating a positive pressure gradient. The steam escapes through cracks, defects, open capillaries and channels in both the cellular structure and membranes. As the process progresses, oil adheres to the food, entering the large voids, product imperfections and crevices left by the changes in structure due to frying and water evaporation [23]. In addition, product porosity plays a significant role in the oil uptake of fried products. $NaHCO_3$ plays a role in leavening agents increasing oil uptake of fried products due to the formation of gas cells that fill with oil during frying [26]. Then, the increase of $NaHCO_3$ concentration causes an increase in fat content of cassava chips. Generally, three mechanisms have been proposed to explain the complex process of oil uptake during deep-fat frying. These include water replacement, cooling-phase effect and surface-active agents [23].

Table 1 Effect of pre-treatment method on moisture content and fat content of cassava chips

Pre-treatment	Moisture content (%)	Fat content (%)
Control	1.09 ± 0.13^b	22.85 ± 0.93^d
Water	1.01 ± 0.08^b	24.32 ± 0.97^c
1% $NaHCO_3$	0.96 ± 0.04^b	28.59 ± 1.50^b
2% $NaHCO_3$	1.42 ± 0.11^a	30.69 ± 1.24^a

Different letters in the same column indicate that values are significantly different from one another ($p<0.05$)

3.2 Physical Qualities

Water activity (a_w) in cassava chips was not significantly different among different the various pre-treatment methods, and instead corresponded largely to moisture content. The a_w of cassava chips is in the range of 0.126 - 0.142 (**Table 2**).

Bulk density and hardness of cassava chips as affected by pre-treatment are shown in **Table 2**. Bulk density of cassava chips was calculated by dividing the weight by the volume of cassava chips. Soaking fresh cassava slices in water and $NaHCO_3$ solution prior to frying caused a decrease of bulk density in cassava chips. The results revealed that the volume of cassava chips increased due to the formation of internal air bubbles. The formation of gas cells in cassava chips was derived from the combination of water pressure and the leavening agent properties of $NaHCO_3$ during the frying process. However, increasing $NaHCO_3$

concentration from 1 to 2% did not affect the bulk density of cassava chips (0.401-0.402 g/cm^3) because frying oil was free to move in to the gas cells of cassava chips during frying. Regardless, both the volume and weight of chips rose simultaneously.

The hardness of cassava chips was evaluated and expressed in breaking force as it relates to the crispness of cassava chips. The hardness of cassava chips without pre-treatment was 558.57 g. Soaking fresh cassava slices in water and $NaHCO_3$ prior to frying yielded a lower hardness value. The hardness of cassava chips decreased from 558.57 to 231.50 g when soaking fresh cassava slices in 2% $NaHCO_3$. Water and $NaHCO_3$ influenced the hardness of cassava chips due to the formation of air bubbles in cassava chips during frying relating to decrease in bulk density of cassava chips. The air cells corresponded to brittleness in cassava chips, with more air cells leading to easier fracturing.

Color (*L**, *a** and *b**) of cassava chips as affected by the pre-treatment method is shown in **Table 3**. The pre-treatment method significantly affected the lightness (*L**) and redness (*a**) of cassava chips. Soaking fresh cassava slices in water prior to frying resulted in a significant increase in the *L** value of

Table 2 Effect of pre-treatment method on water activity, bulk density and breaking force of cassava chips

Pre-treatment	Water activity (a_w)	Bulk density (g/cm^3)	Hardness (g)
Control	0.132 ± 0.010^a	0.496 ± 0.08^a	558.57 ± 86.42^a
Water	0.131 ± 0.020^a	0.399 ± 0.05^b	298.87 ± 63.56^b
1% $NaHCO_3$	0.126 ± 0.033^a	0.402 ± 0.07^b	239.80 ± 54.71^b
2% $NaHCO_3$	0.142 ± 0.017^a	0.401 ± 0.04^b	231.50 ± 36.55^b

Different letters in the same column indicate that values are significantly different from one another ($p<0.05$)

Table 3 Effect of pre-treatment method on color (*L**, *a** and *b**) of cassava chips

Pre-treatment	*L**	*a**	*b**
Control	53.79 ± 0.60^c	2.73 ± 0.43^a	23.17 ± 1.67^a
Water	59.19 ± 1.11^a	1.69 ± 0.42^{bc}	21.23 ± 1.25^a
1% $NaHCO_3$	57.27 ± 2.20^b	1.82 ± 0.42^b	21.70 ± 1.51^a
2% $NaHCO_3$	54.14 ± 2.11^c	1.44 ± 0.18^c	22.82 ± 3.03^a

Different letters in the same column indicate that values are significantly different from one another ($p<0.05$)

cassava chips whereas the a* value decreased significantly ($p<0.05$). The greenness ($b*$) of the cassava chips was not affected by pre-treatment ($p\geq0.05$). Soaking in water increased the lightness of cassava chips due to a reduction of the non-enzymatic browning reaction of fried products in which sugar is leached out and plays an important role in color formation during frying [27]. Santis et al. [28] have found that blanching, and both water and NaCl soaking all produce paler potato chips. Many additional factors might affect the color of the fried products such as frying time, oil temperature, oil type, pre-treatment method, storage conditions, and the variety and maturity of the raw materials [28]. An increase in lightness is related to a decrease of redness in cassava chips.

However, the increase in the concentration of $NaHCO_3$ used to soak fresh cassava slices prior frying led to a decrease in the L* value of cassava chips (**Table 4**) indicating increased darkness of the chips

3.3 Sensory Qualities

The effect of the method of pre-treatment on panelists' sensory scores for cassava chips are shown in **Table 4**. The liking scores of all attributes (appearance, crispness, flavor, taste and overall liking) for cassava chips showed no significantly differences ($p\geq0.05$) among treatment. The liking score of cassava chips in appearance, crispness, flavor, taste and overall liking are in the ranges of 7.07 - 7.47, 7.07 - 7.97, 7.03 - 7.43, 7.00 - 7.87 and 7.47 - 7.93, respectively. The sensory scores of all attributes ranged from 7.00 - 8.00, indicating that panelists liked cassava chips moderately to very much. In this experiment, $NaHCO_3$ could be used at a concentration no higher than 2% to pre-treat fresh cassava slices because it affected the taste of cassava chips. Although, using $NaHCO_3$ solution could reduce the hardness of cassava chips, the sensory quality of chips with and without pre-treatment didn't change significantly.

Pearson's correlation coefficients (r) were analyzed to quantify the relationship between pre-treatment method and liking score in cassava chips (**Table 5**). Pre-treatment method revealed significant negative correlations with liking score of crispness and taste. The liking scores of all attributes (appearance, crispness, flavor and taste) were significantly positive correlations with overall liking scores.

Table 4 Effect of pre-treatment method on liking scores in cassava chips

Pre-treatment	Appearance ^{ns}	Crispness ^{ns}	Flavor ^{ns}	Taste ^{ns}	Overall liking ^{ns}
Control	7.07 ± 1.51	7.97 ± 1.03	7.43 ± 1.41^{a}	7.87 ± 1.10^{a}	7.93 ± 1.11^{a}
Water	7.07 ± 1.31	7.57 ± 1.22	7.30 ± 1.11^{a}	7.50 ± 1.33^{a}	7.63 ± 1.18^{a}
1% $NaHCO_3$	7.47 ± 1.20	7.07 ± 1.64	7.03 ± 1.35^{a}	7.00 ± 1.55^{a}	7.50 ± 1.22^{a}
2% $NaHCO_3$	7.47 ± 1.20	7.37 ± 1.47	7.14 ± 1.33^{a}	7.03 ± 1.47^{a}	7.47 ± 1.31^{a}

^{ns} indicate that values in the same column are not significantly different ($p \geq 0.05$)

Table 5 Pearson's correlation coefficients between pre-treatment method and liking scores in cassava chips

Attributes	Pre-treatment	Appearance	Flavor	Crispness	Taste
Appearance	0.137				
Flavor	-0.101	0.625*			
Crispness	-0.187*	0.391*	0.543*		
Taste	-0.240*	0.452*	0.566*	0.666*	
Overall liking	-0.142	0.631*	0.747*	0.691*	0.833*

* $p<0.05$ (two-tailed)

4. Conclusion

The pre-treatment had a significant effect on the qualities of cassava chips. Soaking cassava slices in water and sodium bicarbonate solution prior to frying increased moisture and fat content in cassava chips. The bulk density and hardness of cassava chips decreased with pre-treatment. However, pre-treatment did not change significantly on sensory quality of the cassava chips.

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