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Dimension and stackability of cassava (*Manihot esculanta* Crantz) chips for mass production

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Abstract

Cassava chips that exist in the current market have no standardisation and cannot be stacked nicely into cylindrical container. The objectives of this work are to determine the different dimension of cassava chips produced with different thickness and to develop stackable chips during mass production. Fresh cassava tubers were harvested, washed, peeled and sliced. The thickness measurements used were 1.0 mm, 1.5 mm, 1.75 mm and 2.0 mm and 1.27 mm thickness was measured from commercial potato chips as a controlled sample. Then, it was fried in deep fat fryer with the temperature of 170°C. For each thickness studied, different numbers of slice (10, 20, 30 and 40 slices) were fried simultaneously. Results showed that there are 6 shapes of fried chips produced during the frying. To conclude, thickness of the slice and number of slices fried simultaneously give impact towards the shape of fried chip.

Introduction

Cassava or its scientific name, *Manihot esculanta* Crantz, is distributed from northern Argentina to the southern United States of America (FAO, 2013). Various parts of cassava tree (root to leave) can be processed to be food. One of the commonly used cassava parts is its roots which are normally harvested 10-12 months after planting. According to the Food and Agriculture Organization (2014), cassava is the third most important source of calories in the tropics countries, after rice and corn.

There is an increase of 44% in cassava harvesting area around the globe since 1980 to 2011 (FOA, 2013). Africa is the leader for the world cassava production followed by Latin America and Asia. In Asia, Thailand produces the highest cassava production starting 2012 compared to Indonesia and other Asian countries (FAO, 2014). Cassava is consumed in many forms for instance in the form of fresh roots and flour based product. One of the products that can be produced from fresh root of cassava is chips. Fried chips are made by deep frying slices of cassava tubers in oil which has been heated at high temperature (Vitrac *et al.*, 2002). According to Euromonitor (2011) there is an increasing in sales of sweet and savoury snacks focusing on chips from 2006 to 2011 in Malaysia.

There are various parameter attributes to determine the quality of cassava chips such as thickness, diameter of sliced tuber, time and the temperature during frying process. Vitrac *et al*. (2002) stated that different thickness (1.0 mm, 1.5 mm and 2.0 mm) of fried cassava slices at 160°C in palm oil will increase the frying time. As a result, there will be different effects on the final quality of chips in term of colour, texture and oil uptake. This is due to the different amount of water removed during frying process as a result of the difference in slice thickness (Vitrac *et al*., 2001).

Cassava chips are produced by peeling and slicing cassava tubers before deep frying. Thus, the shapes of the fried slices are not similar as it depends on the natural structure of the cassava tuber. Consequently, the fried cassava slice cannot be stacked evenly in cylindrical containers. Eventually, the final product will become less attractive even though it is packed in an attractive container.

In contrast, potato chips which are formulated using additional specific ingredients are shown to have better stacking ability. They are processed using a number of ingredients for instance salt and flour to transform it from the natural potatoes to chips. Hence, they can control the texture of the finished product and can develop specified textures and structures that are not found in native foods (Bourne, 2002). This

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is known as fabricated product. The consistency in shape of chips is important to attract consumer in making their choice to buy a can of stackable cassava chips.

The inconsistency of shape will reduce the attractiveness and appearance of the product. Stackable and standardised chips are required for better packing in cylindrical container at the same time to protect the chips from breakage during transportation process. Unfortunately, there is no commercial sliced cassava chip product with good stacking characteristics available in the market. Therefore, the objectives of this work are to determine the different dimension of cassava chips produce during mass production with different thickness and to develop equal standard and stackable chips for mass production.

Materials and Methods

Samples preparation

Cassava tubers were purchased from Sepang after being planted for 8 months. The outer part (yellow flesh) of the cassava tubers were washed, peeled manually using a hand peeler and further sliced using a rotatory slicer (Barkel, inc) with four different thicknesses measurement; 1.0 mm, 1.5 mm, 1.75 mm and 2.0 mm. The shape of the slices is categorised as ellipse shape with standardized major and minor diameter of 5.0 cm and 4.8 cm respectively. Commercial potato chips were used as reference in term of the desirable stacking condition, size and shape.

Frying procedure

A household deep fat fryer (Model HD6159, Philips) equipped with an electric resistance of 2000W effective power submerged at the bottom of the fryer was filled with 3 litre palm oil. The frying temperature was set at 170^{o}C and the oil temperature was controlled using the oil thermometer. The oil was preheated and maintained at the processing temperature (170^{o}C) before frying. Mass production of fried cassava chips which involved production of large amounts of cassava slice for frying was applied in this research. Four-different quantities (total number of tuber slices) used were 10, 20, 30 and 40 slices for each thickness was fried simultaneously. A programmable data logger (ValSuitte) was used to record the temperature and to regulate the oil bath temperature during the frying processes. Two thermocouples were placed at different positions in the fryer to measure the temperature during frying. After the fry, the chips were blotted with paper towels to remove excess surface oil. The oil level was checked and replenished after every frying test. Besides, to minimize variations of oil properties due to degradation, the oil was renewed after 3 times of frying.

Analysis of cassava chips

Fat content

Fat content was determined by Soxhlet extraction method (AOAC, 2008). The fat content was calculated in percentage based on the dry basis.

Moisture content

The sample was blended and 3 grams of the sample were taken and dried in an oven at 105^{o}C until it reached its constant weight. The samples were then cooled in desiccators and be weighed. Moisture content was calculated based on percentage of the wet-weight.

Stackability test

Ten chips were stacked vertically in between the clamped hard card. A retort stand was used to hold the chips with two cards placed parallel to each other. Then, the distance between two cards was taken using digital calliper (model Kern, 0-150 mm, Germany). The stackability value can be calculated as follows: total distance of chips divided by numbers of chips. Lower values represent better ability to stack.

Statistical analysis

Analysis of variance (ANOVA) was carried out using MINITAB software. Statistical significance was expressed as $p<0.05$. All the measurements in this study were performed in triplicate.

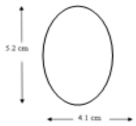
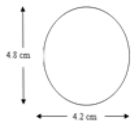
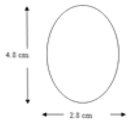
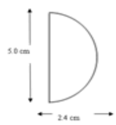
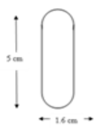
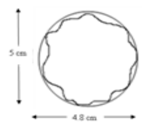
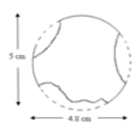
Results and Discussion

Frying process of sliced cassava chips

Several processes occurred during frying of cassava slice. The heating process started when slices of cassava submerged in high temperature oil (170^{o}C) whereby the convection process of heat transfer taken place. Then, the surface of cassava slices began to evaporate and the heating process changes from natural convection to forced convection due to turbulence in oil that surround the slices.

Figure 1 showed that the oil temperature decreased as the number of cassava slices increased during the frying process. The frying amount of time required to fry a higher number of slices is longer. Increased in ratio of the number of slices to volume of oil (weight/volume) reduces the final frying temperature (Ziaiifar *et al*., 2008; Pedreschi and Moyano, 2005).

Table 1. Different shape for chips produced during mass production

	Control	A	B	C	D	E	F
Shape							
Sample picture							
Description	Have an ellipse shape. Not folded but have little curve.	The shape represents the control shape for cassava chips. Have an ellipse shape with little curve which similar to control.	Have a 'U' shape. If minor diameter: < 2.8 cm; classified as B shape. ≥ 2.8 cm; classified as an A shape.	Have a 'D' shape. The chip is folded into half from its original shape.	Have an 'I' shape. The chip is folded into one third from its original shape.	Have an 'O' shape. Have wrinkles and wave around the end of chips.	Has a flat surface but it has some folded part at the ends of chips.

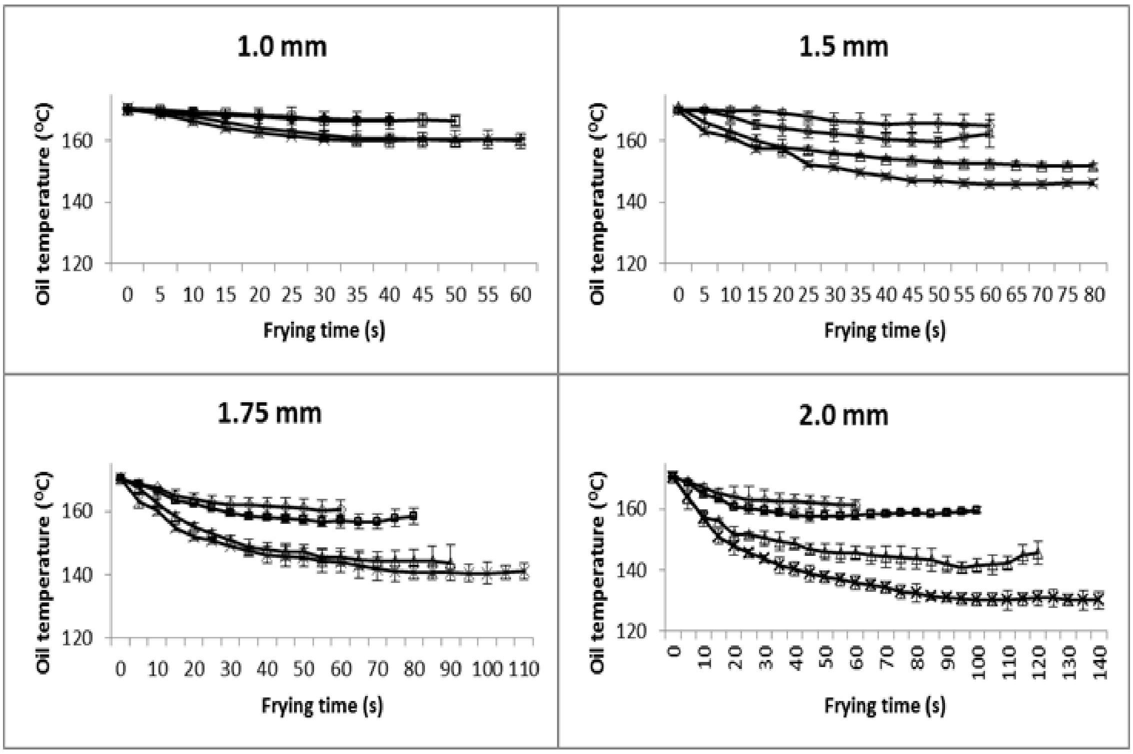


Figure 1. Changes in oil temperature as related to frying time of slice cassava [10 pieces (◊), 20 pieces (□), 30 pieces (Δ) and 40 pieces (X)]

At this stage, several physicochemical changes can take place including the increase in the thickness of the superficial crust and diminishes of speed of steam transfer on the surface. The final shape of chips was also influenced by this process and a variety of shape was produced after frying. Finally, the humidity elimination speed diminishes and no bubble was observed on the surface of the food (Alvis *et al.*, 2009). In this study, final frying temperature for frying chips was monitored after the bubbling of hot oil diminished i.e. in the range of 40 s to 140 s after the tubers slices were immersed in the frying oil.

Different chips shape and dimension in mass production

Shrinkage process is a decrease in product dimension which occurs when the amount of water loss in slice during early stage of frying and the

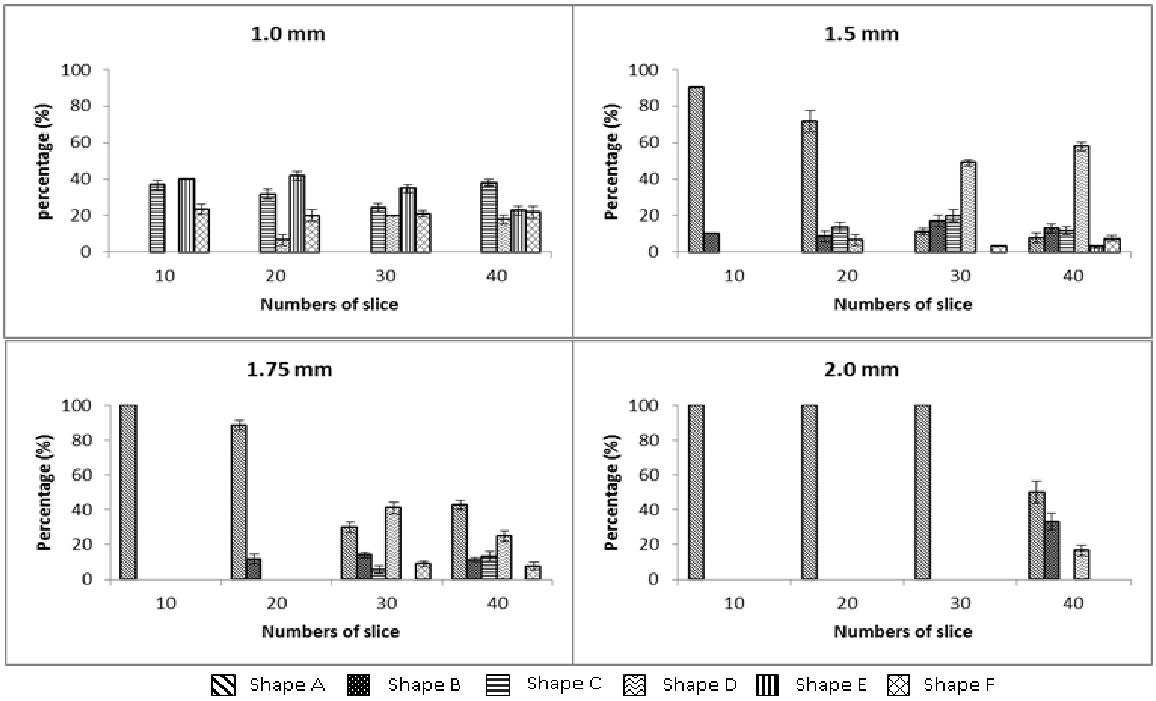


Figure 2. Percentage of shapes produced after frying slice cassava tuber with different thickness and numbers of slice

changes in slice increased with frying time (Taiwo and Baik, 2007). During frying, little expansion may be produced by the superheated vapour trying to escape the pore space (Sobukola *et al*., 2008). Expansion occurs in the after the initial shrinkage and both process is continuously take place during frying (Taiwo and Baik, 2007; Math *et al*., 2004; Yamsaengsung and Moreira, 2002). Changes in shape of slice during frying occur because the shrinkage and expansion process and it does depend on quantity in numbers and thickness of slice respectively that attribute to the final shape of chips.

Different shape obtained after frying slice cassava with different thickness and numbers of slice as described in Table 1. What is interesting in this data was after frying process, there were 6 shapes produced and it has been classified as shape A, B, C, D, E and F which never been study in previous research. Shape A has a shape similar to the control (formulated potato chips) shape as the reference after each frying process.

Figure 2 compares the percentage of 6 shapes produce after frying in different thickness and numbers of slice. Shape A can produced better (as a control description) stackable properties compared to others shape. This figure proves that only slice with thickness of 1.5 mm, 1.75 mm and 2.0 mm can produce shape A. For thickness 1.5 mm and 1.75 mm, using 10 slices of cassava produced higher shape A. Furthermore, the percentage of shape A production with thickness of 1.5 mm and 1.75 mm decreased as the increase in the numbers of slice. But, for thickness 2.0 mm the production of shape A is constant for 10, 20 and 30 number of slices.

During initial stage of frying, most of the cassava tissue softened and became cooked, and a later stage in which the crust formation starts and progressively hardened (Pedreschi and Moyano, 2005; Baumann and Escher, 1995). During the slicing process, shape for thickness 1.0 mm was too thin which make it already curvy at the end of each slice and this contributes to the changes of slices in various shape dramatically in frying process. The more chips fried at the same time, the ratio of oil and slice inside the fryer increased. Thus, the position of slices is very close to each other and this can give different shapes formation. Shortly, it is important to control the ratio of cassava to oil through its weight or numbers of slice during frying to ensure there was enough space for slice to expand in a good shape.

Stackability of chips

Figure 3 shows the stackability value of cassava chips for different thickness and numbers of slice. The lowest values indicate that the chips have good stackability and contribute to higher amount of chips that can fill up in cylindrical container. The thickness 1.0 mm was eliminated in this experiment because it cannot produce any A shape. Thickness 1.75 mm for 10 slices shows the lower value among other thickness. But, there are no significant differences between all thicknesses for 10 and 20 slices. For

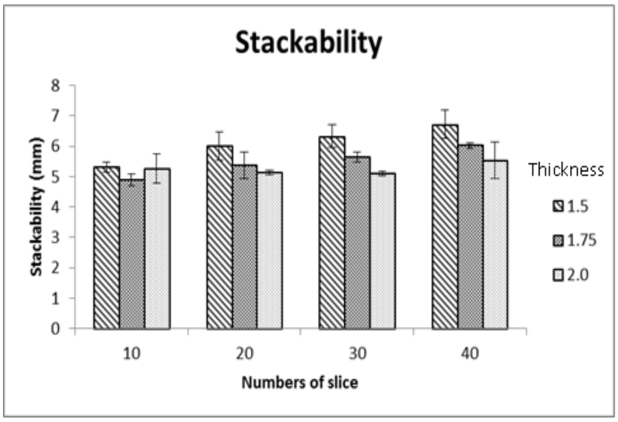


Figure 3. Stackability of chips in different thickness and numbers of slice

thickness 1.75 mm and 2.0 mm there are also no significant different for 30 slices. As a conclusion, 30 slices with 2.0 mm thickness is the best formulation for mass production of chips with better stackability.

Conclusion

It can be concluded that the thickness and numbers of slice cassava fried simultaneously can affect the dimension and stackability of fried chips. Shape A is an acceptable dimension that can produce stackable chips, with 2.0 mm thickness of sliced cassava tuber and 30 slices of cassava tuber fried simultaneously using the deep fryer. Ratio of slices to oil during frying is crucial to produce better shape of chips that can be stacked in order to satisfy the consumer request. Furthermore, this can contribute to the stacking of chips and filled up more in cylindrical containers. These findings can benefit in helping small and medium industries (SME) to boost up their sales and production efficiency. The product can also be exported using an attractive packaging even it is costly, it gives more protection and be more durable compared to the usage of common type of flexible plastic packaging.

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