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# Quality evaluation of deep fried chips produced from lotus rhizome

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**Abstract**

The main objective of the present study was to produce crispy deep fried chips from lotus rhizome with acceptable organoleptic qualities. Effects of three different frying temperatures (180, 190 and 200°C, for 15-20 sec) on the overall qualities (proximate composition, texture and sensory) of lotus rhizome chips were determined. Prior to frying, freshly procured rhizomes were sliced uniformly (thickness of ~2.5 mm, diameter ~ 5.2mm), blanched in hot water (85°C for 3.5 min) and dried in a hot air vacuum oven (60°C, 24 h). Results on textural studies showed force required to break the chips to be dependent on temperature. Sensory quality results revealed high acceptability for chips produced by frying at 200°C. This reported work being a preliminary study, further research works is warranted to standardize the protocols for industrial scale production of lotus rhizome chips, with improved taste and flavour, keeping in mind the safety and quality issues.



## Introduction

Lotus plants (*Nelumbo nucifera* Gaertn., family; Nymphaeaceae) are large aquatic herbs, which are widely distributed in China, India, Japan, and in some parts of South-East Asia. Lotus plant parts (seeds, flowers, stem and rhizome) find wide applications and are used either as vegetable or in indigenous medicine systems (e.g. Traditional Chinese Medicine or Ayurvedic medicine) (Sridhar and Bhat, 2007; Bhat and Sridhar, 2008). Traditionally, lotus rhizomes (roots) are consumed after roasting or are used as vegetable to prepare curries, spicy pickles, etc. Lotus rhizome encompasses rich amount of polyphenolic compounds, which exhibit rich antioxidant properties (Hu and Skibsted, 2002; Mukherjee *et al*., 2009).

Today, world over, people are relying more on consuming ‘ready-to-eat’ snack foods. The most popular among these are the potato chips or crisps, which are taken as an appetizer or as a snack food (Salvador *et al*., 2009). By witnessing the trends, chips have become one of the prominent food industry investments too. Of late, consumers are constantly looking for newer, low fat- healthier snack foods to satisfy their taste buds. Based on these, the main objective of undertaking the present study was to produce a new healthy snack food product in the form of fried chips, by using lotus rhizome with acceptable sensory qualities, expected to be useful for both consumers and the industry.

## Materials and Methods

### *Materials*

Fresh lotus roots (rhizome) and sunflower oil were purchased from a local supermarket in Penang Island, Malaysia. For preparing chips, only healthy lotus rhizomes without any apparent physical damage were used. The detailed protocol employed for producing chips is highlighted in Figure 1.

### *Pre-treatments for producing chips*

We adopted the method reported by Pedreschi and Moyano (2005a,b) with slight modifications to prepare lotus rhizome chips. In brief, lotus rhizomes (6-8 numbers) were surface cleaned by washing with running tap water followed by wiping in a clean cloth. Further, with the help of a sterile stainless steel knife, rhizomes were peeled and thinly sliced to obtain a uniform size (thickness of ~2.5 mm, diameter ~ 5.2mm). These slices were immediately rinsed in distilled water for approximately 1 min to remove loose starch that might be adhering to the surface. This

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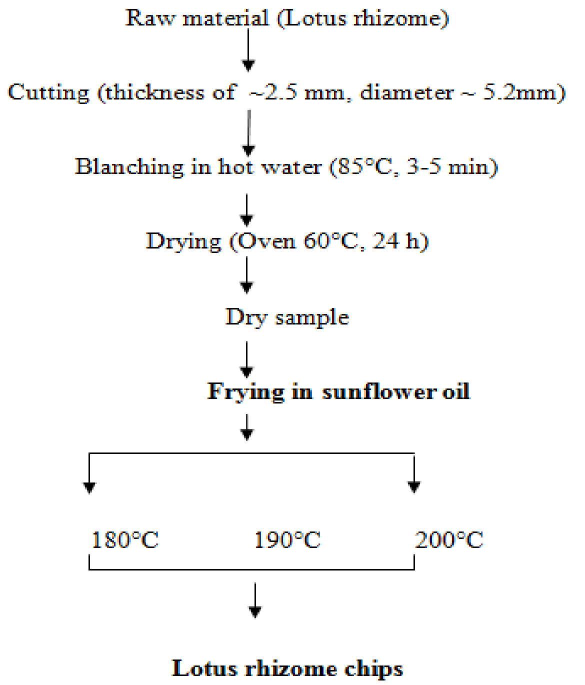


Figure 1. Flow chart indicating the protocol involved in producing lotus rhizome chips

was followed by blanching, which was prepared by immersing raw slices in hot water at 85°C for 3.5 min with lotus-to-water ratio being ~0.005 w/v. Blanched slices were removed and blotted thoroughly (using a blotting paper) to remove any of the adhering materials on the surface, prior to drying. Pre-dried samples were prepared by placing blotted blanched slices in hot air oven trays (arranged in one single layer) and dried in vacuum oven at a temperature of 60±1°C for 24 h. Weight loss was monitored continuously until the slices reached a constant moisture level. Sliced rhizome samples, rinsed in water without blanching served as control. According to Pedreschi *et al.* (2004), blanching treatments can be highly efficient in reducing browning of the fried products (such as for chips) by leaching out 'Maillard' reactants that can play a significant role in determining the colour and acrylamide formation during frying.

*Frying conditions*

The method reported by Pedreschi and Moyano (2005a,b) with some minor modifications was employed for frying and preparing chips. Dried samples (control and blanched slices) were deep-fried (5-6 slices each time) in pre-heated sunflower oil (~ 2 liters) for 15-20s in a non-stick, round bottomed frying pan at temperatures of 180, 190 and 200°C. These temperature range was fixed based on the results of preliminary experiments conducted at different temperatures to standardize the production of lotus rhizome chips (which was found to be >170°C, results not provided). Thin slices obtained were deep-fried until a light brown colour with a unique, pleasant aroma was developed. Slices-to-oil weight ratio was retained low (~0.004) to maintain a constant frying temperature (±1°C). After frying, the chips were drained of excess oil by placing on a stainless steel wire mesh (3-4 min) and cooled to room temperature (25±1°C) before performing any analysis.

*Proximate analysis of raw and deep fried chips*

Lotus rhizome (raw and deep fried chips) was analyzed for chemical composition (moisture, crude protein, fat, fiber, ash) by employing AOAC method (1990). Crude protein content was determined by micro-Kjeldhal method, while fat content was estimated by Soxhlet method using petroleum ether as an extracting solvent. The ash content was determined by incineration at 550°C by using muffle furnace (AOAC, 1990). Available carbohydrate and energy values (Gross energy, GE, kcal) were calculated based on difference (Bhat and Sridhar, 2008):

Carbohydrate = 100 – [crude protein (%) + crude lipid (%) + crude fiber (%) + ash (%)] and

GE (kJ/100g) = (protein x 16.7) + (lipid x 37.7) + (carbohydrate x 16.7

*Texture analysis*

Texture measurements of the chips were performed at room temperature (~25±1°C) by employing puncture test, with slight modifications (Segnini *et al.*, 1999). The measurements were performed by using a computer assisted TA XT-Plus Texture Analyzer (Stable Micro Systems, UK) with a 5-kg-load cell. Fried chips were mounted individually on a three-point-support, at a distance maintained at 15mm with the punch diameter and the cross-head speed being 2mm and 60mm/min, respectively. Force versus distance curves was generated based on the puncture test and data was analyzed by using inbuilt software of the texture analyzer.

*Sensory evaluation*

Lotus chips samples prepared at three temperatures of 180, 190 and 200°C were transferred to a clean plate and left for 2-3 min by placing on a stainless steel wire mesh (to drain off excess oil). This was cooled to room temperature before conducting sensory quality evaluation. A trained panel of students and technical staff (from Food Technology Division, Universiti Sains Malaysia) evaluated the samples for different sensory attributes such as colour, odour, taste, texture, and overall acceptance (using 7 hedonic scale). All the samples were blindly coded using a three-digit number.

Table 1. Proximate composition of lotus rhizome (raw) and fried chips (g/100g) (n=3± s.d.)

| Composition | Raw | Chips | | |
|---|---|---|---|---|
| | | 180°C | 190°C | 200°C |
| Moisture | 23.36±0.2ª | 4.80±3.3ᵇ | 3.94±0.5ᶜ | 3.48±0.5ᶜ |
| Protein | 2.20±0.4ᶜ | 4.78±0.2ª | 3.19±0.8ᵇ | 3.44±0.1ᵇ |
| Crude lipid | 0.50±0.2ᶜ | 21.78±0.5ᵇ | 23.15±2.7ª | 23.00±1.4ª |
| Crude fiber | 33.91±5.4ª | 3.93±1.4ᵇ | 3.70±1.4ᵇ | 3.39±0.6ᵇ |
| Ash | 1.04±0.0ᵇ | 1.90±0.5ª | 1.86±0.1ª | 1.85±0.2ª |
| Carbohydrate | 62.35±6.1ᵇ | 67.61±1.7ª | 68.10±4.4ª | 68.32±1.9ª |
| Energy (kcal) | 1096.8±20.9ᵇ | 2033.36±9.3ª | 2063.30±7.4ª | 2065.50±5.3ª |

Same letters in the same row indicates that values are not significantly different from each other (P > 0.05)

*Statistical analysis*

All the analysis reported in this study was performed in triplicates and data obtained is reported as mean ± standard deviation. One-way ANOVA was used to determine the statistical significance of the results. Duncan means comparison test was applied to determine the difference between the mean values at a significant level of $P<0.05$ using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

## Results and Discussion

*Frying oil*

Deep frying in oil is one of the most popular techniques, used to prepare tasty and crispy snack foods (Pedreschi and Moyano, 2005 a,b). Cooking oil used for frying plays a significant role in imparting unique taste, aroma and flavour to the fried product. According to Hubbard and Farkas (1999), high heat transfer rate can significantly contribute to the development of vital organoleptic properties in fried products. Plant based vegetable oils is reported to be a good source of omega 6- (linoleic acid) and omega 3- (alpha linolenic acid) fatty acids, along with the presence of essential macro- and micro-nutrients (vitamin E, phytosterols) (Combe and Rossignol-Castera, 2010). Also, frying oil possessing bound linoleic acid tends to generate unique taste and flavour in the product (Warner *et al*., 1997). Sunflower oil is one of the most popular and widely used cooking oil, known to posses' high degree of oxidative stability. Sunflower oil is reported to have high linoleic acid and linoleic acid contents (Fuller *et al*., 1967). This oil is rich in tocopherol, mono-and polyunsaturated fatty acids and does not contain any cholesterol. Sunflower oil is desirable for frying purposes, especially for the snack items, which requires long-term storage. Hence, this was the reason we selected sunflower oil for frying lotus rhizome and for preparing chips in this study.

Results on the proximate composition of the raw material used as control (i.e., lotus rhizome) and the deep fried chips are provided in Table 1. Results showed reduction in moisture (from 23.36 to 3.48 g/100 g) and crude fiber contents (33.91 to 3.39 g/100 g) with a corresponding increase in protein, fat, ash, carbohydrate and energy values compared to control samples. This increase can be attributed to the loss of moisture resulting from dehydration that occurs during frying process. Low moisture content is desirable and will be advantageous to extend the shelf-life and stability of the product. Generally, moisture and lipid contents are vital quality parameters that determine the acceptability and shelf-life of a product, especially like those of oil fried chips. Earlier, Gamble and Rice (1988) have reported that thin slices of raw material (such as those used for making chips) can result in diffusion of moisture to shorter distances on the materials surface (during frying), which can ultimately lead to rapid moisture loss. Also, water content (moisture) tends to evaporate immediately as soon as the raw material gets in contact with the hot frying oil. Surface interactions that occur between oil and the raw material has been reported to be influenced by the vigorous movements of water vapour that tends to escape from the raw material into the oil (Sharma *et al*., 2000). However, between the three treatment temperatures, not much variation (insignificant) was observed with regard to oil uptake. This might be attributed to the uniform thickness (thickness of ~2.5 mm, diameter ~ 5.2mm) that was maintained during slicing of the raw materials. Additionally, oil content in a product can depend on the frying temperature, frying time as well moisture content (Moreira *et al*., 1997; Sharma *et al*., 2000; Yagua and Moreira, 2011). According to Baumann and Escher (1995), dehydration achieved by frying in hot oil at temperature ranging between 160-180°C is characterized by high drying rates, which can be very critical to ensure favorable textural properties of the product.

*Texture analysis*

Texture (crispiness) of chips is a vital criterion that determines the consumers' acceptance (Setiady *et al*., 2009). Generally, texture of chips is determined either by instrumental methods (puncture test) or by using sensory evaluation (Szczesniak *et al*., 1963). In this study, during frying of the lotus rhizome, initially softening of the tissue was observed, which was an indication of initiation of cooking process, which was followed by crispy, crust formation at high temperatures. The relationship between temperature and texture (maximum force of break) is dependent

Table 2. Sensory quality evaluation of deep fried lotus rhizome chips (n=30±s.d.)

| Temperature of frying (°C) | Appearance | Colour | Flavour | Texture (Crispiness) | Overall acceptability |
|---|---|---|---|---|---|
| 180 | $5.93 \pm 0.52^{a}$ | $7.87 \pm 0.35^{b}$ | $4.90 \pm 0.30^{c}$ | $4.40 \pm 0.56^{b}$ | $5.07 \pm 0.58^{c}$ |
| 190 | $5.73 \pm 0.58^{b}$ | $8.27 \pm 0.64^{a}$ | $5.40 \pm 0.50^{b}$ | $4.87 \pm 0.50^{a}$ | $6.03 \pm 0.41^{b}$ |
| 200 | $5.93 \pm 0.45^{a}$ | $7.87 \pm 0.50^{b}$ | $5.73 \pm 0.54^{a}$ | $4.97 \pm 0.66^{a}$ | $7.33 \pm 0.54^{a}$ |

Same letters in the same column indicate that values are not significantly different from each other (P > 0.05)

on drying or removal of moisture from the raw material. Deep oil frying at a specified temperature at a certain fixed time can induce unique texture and flavour in the food product. Earlier, it has been reported that improvement in texture and reduction in oil uptake of chips to be dependent on the blanching process involved (Califano and Calvelo 1987; Agnlor and Scanlon, 2000; Leeratanarak *et al*., 2006), which holds true in the present work too.

*Sensory evaluation*

Sensory evaluation studies reported here is based on the evaluation by 30 trained panelists. Development of desirable sensorial properties in fried products is attributed to high heat transfer rates (Hubbard and Farkas, 1999). Table 2 shows results on the ratings of sensory attributes for each lotus rhizome chips prepared by frying at different temperature range. The results of the sensory evaluation showed significant differences (P<0.05) between the samples analyzed. Overall, chips produced by frying at 200°C showed high score for flavour, texture and overall acceptability.

## Conclusion

Outcome of the present study resulted in the development of lotus rhizome chips with acceptable quality characteristics. In the world market, as potato chips remains popular, it is envisaged that lotus rhizome chips might also find its way as a healthy food snack. Future studies is warranted to develop appropriate methods and processes of blanching and frying to decrease oil content and uptake, along with studying the kinetics of texture development in the lotus rhizome chips. Studies are also required which are aimed towards determining and minimizing acrylamide contents in chips on/ during frying.

## References


Agnlor, A. and Scanlon, M. G. 2000. Processing conditions influencing the physical properties of French Fried potatoes. Potato Research 43: 163-178.

AOAC. 1990. Official Methods of Analysis (15th ed.) Washington, DC: Association of Analytical Chemists.

Baumann, B. and Escher, E. 1995. Mass and heat transfer during deep fat frying of potato slices I. Rate of drying and oil uptake. LWT - Food Science and Technology 28: 395-403.

Bhat, R. and Sridhar, K. R. 2008. Nutritional quality evaluation of electron beam-irradiated lotus (*Nelumbo nucifera*) seeds. Food Chemistry 107: 174-184.

Califano, A. N. and Calvelo, A. 1987. Adjustment of surface concentration of reducing sugars before frying of potato strips. Journal of Food Processing and Preservation 12: 1-9.

Combea, N. and Rossignol-Castera, A. 2010. Vegetable oils and frying. Cahiers de nutrition et diététique 45: S44-S51.

Fuller, M., Diamond, J. and Applewhite, T. 1967. High oleic sunflower oil. Stability and chemical modification. Journal of the American Oil Chemists' Society 44: 264-267.

Gamble, M. H. and Rice, P. 1988. The effect of slice thickness on potato crisp yield and composition. Journal of Food Engineering 8: 31-46.

Hu, M. and Skibsted L.H. 2002. Antioxidative capacity of rhizome extract and rhizome knot extract of edible lotus (*Nelumbo nucifera*). Food Chemistry 76: 327-333.

Hubbard, L. J. and Farkas, B. E. 1999. A method for determining the convective heat transfer coefficient during immersion frying. Journal of Food Process Engineering 22: 201-214.

Leeratanarak, N., Devahastin, S. and Chiewchan, N. 2006. Drying kinetics and quality of potato chips undergoing different drying techniques. Journal of Food Engineering 77: 635-643.

Moreira, R.G., Sun, X. and Chen, Y. 1997. Factors affecting oil uptake in tortilla chips in deep-fat frying. Journal of Food Engineering 31: 485-498.

Mukherjee, P.K., Mukherjee, D., Maji, A.K., Rai, S., Heinrich, M. 2009. The sacred lotus (*Nelumbo nucifera*)-Phytochemical and therapeutic profile. Journal of Pharmacy and Pharmacology 61: 407-422.

Pedreschi, F., Kaack, K. and Granby, K. 2004. Reduction of acrylamide formation in potato slices during frying. LWT - Food Science and Technology 37: 679-685.

Pedreschi, F. and Moyano P. 2005a. Effect of pre-drying on texture and oil uptake of potato chips. LWT- Food Science and Technology 38: 599-604.

Pedreschi, F. and Moyano P. 2005b. Oil uptake and texture development in fried potato slices. Journal of Food Engineering 70: 557-563.

Salvador A., Varela, P., Sanz, T. and Fiszman, S.M. 2009. Understanding potato chips crispy texture by simultaneous fracture and acoustic measurements, and sensory analysis. LWT - Food Science and Technology 42: 763-767.

Segnini, S., Dejmek, P. and Öste, R. 1999. Reproducible Texture Analysis of Potato Chips. Journal of Food Science 64: 309-312.

Setiady, D., Tang, J., Younce, F., Swanson, B.A., Rasco, B.A. and Clary, C. D. 2009. Porocity, colour, texture and microscopic structure of russet potatoes dried using microwave vacuum, heated air, and freeze drying. ASABE Applied Engineering in Agriculture 25: 719-724.

Sharma, S.K., Mulvaney, S.J. and Rizvi, S. S. H. 2000. Frying of foods. In: Food Process Engineering Theory and Laboratory Experiments. Wiley, New York, NY, pp 259-267.

Sridhar, K.R. and Bhat, R. 2007. Lotus - A potential nutraceutical source. Journal of Agricultural Technology 3: 143-155.

Szczesniak, A. S., Brandt, M. A. and Friedman, H. H. 1963. Development of standard rating scales for mechanical parameters of texture and correlation between the objective and the sensory methods of texture evaluation. Journal of Food Science 28: 397-403.

Warner, K., Orr, P. and Glynn, M. 1997. Effect of fatty acid composition of oil on flavour and stability of fried foods. Journal of the American Oil Chemists' Society 74: 347-356.

Yagua, C.V. and Moreira, R.G. 2011. Physical and thermal properties of potato chips during vacuum frying. Journal of Food Engineering 104: 272-283.