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.

Keywords
Lotus rhizome chips frying oil texture sensory quality

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
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):

\[
\text{Carbohydrate} = 100 - \left[\text{crude protein (%)} + \text{crude lipid (%)} + \text{crude fiber (%)} + \text{ash (%)}\right]
\]

\[
\text{GE (kJ/100g)} = (\text{protein x 16.7}) + (\text{lipid x 37.7}) + (\text{carbohydrate x 16.7})
\]

**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.
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 possess’ 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.

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

<table>
<thead>
<tr>
<th>Composition</th>
<th>Raw</th>
<th>100°C</th>
<th>100°C</th>
<th>200°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>23.36±0.2 g</td>
<td>4.81±0.3 g</td>
<td>3.94±0.5 g</td>
<td>3.48±0.5 g</td>
</tr>
<tr>
<td>Protein</td>
<td>2.20±0.4 g</td>
<td>4.78±0.2 g</td>
<td>3.19±0.6 g</td>
<td>3.44±0.6 g</td>
</tr>
<tr>
<td>Crude lipid</td>
<td>0.50±0.2 g</td>
<td>2.78±0.5 g</td>
<td>2.15±0.2 g</td>
<td>2.00±0.1 g</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>33.91±3.5 g</td>
<td>3.93±1.4 g</td>
<td>3.70±1.4 g</td>
<td>3.59±0.6 g</td>
</tr>
<tr>
<td>Ash</td>
<td>1.04±0.0 g</td>
<td>1.90±0.5 g</td>
<td>1.86±0.1 g</td>
<td>1.85±0.2 g</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>6.2±1.5 g</td>
<td>57.6±1.7 g</td>
<td>68.10±4.4 g</td>
<td>68.32±1.8 g</td>
</tr>
<tr>
<td>Energy (Kcal)</td>
<td>1096±0.20 g</td>
<td>2033.36±4.3 g</td>
<td>2053.30±7.3 g</td>
<td>2065.50±5.3 g</td>
</tr>
</tbody>
</table>

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

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 3.59 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
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


Washington, DC: Association of Analytical Chemists.


