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Research Article

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Possible Application of Hydrocolloid Edible Coating Layer to Enhance the Quality of Fried Lotus Rhizome

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Abstract: There is an increasing demand for healthier and functional products. Lotus (*Nelumbonucifera*) rhizome is as a case in point. It's well naturally adapted in swamp regions as one of major crops in Mekong delta, Vietnam. It is rich in carbohydrates, essential minerals, soluble fibers, antioxidants, phytochemical constituents such as polyphenolics and oligomeric procyanidines. It's extensively utilized as a traditional herbal medicine due to its strong antioxidant effect. Very small portion of total lotus rhizome cultivation undergo industrial processing. The processing of lotus parts into value added products must be encouraged to improve the market efficiency, generating employment for local laborers and accelerating income for rural farmers. During frying, oil absorption leads to negative effects in its flavour, odour and general organoleptic properties. The aim of this research was to investigate the in? uence of various hydrocolloids such as carrageenan, carboxymethyl cellulose, sodium alginate as edible coating layer to enhance the quality of fried lotus rhizome with respect to moisture reduction, oil uptake and overall acceptance. Different edible coating substances such as carrageenan, carboxymethyl cellulose, alginate in different concentrations (0.75%, 1.0%, 1.25%, 1.5% w/v) were examined on the lotus rhizome before frying at 190°C for 2.5 minutes in sunflower oil. Our results revealed that 1.25% carboxymethyl cellulose was appropriate for coating of the lotus rhizome. From this investigation it was hoped that, the functional and economic values of lotus rhizome would be enhanced.

Keywords: Lotus rhizome, carrageenan, carboxymethyl cellulose, alginate, coating, frying

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1. INTRODUCTION

Lotus (*Nelumbonucifera*) plants are the large aquatic herbs, widely cultivated in Vietnam and other Southeast Asia regions. It's rhizomes remain fixed within the muddy bottom of the water bodies and the leaves float over the surface of water[1]. Lotus plants propagated vegetatively through rhizomes[2]. Their seed, flower, stem and rhizome have been used as vegetable and for pharmaceutical purposes. Lotus rhizome is rich in starch as well as in vitamins, phospholipids, flavonoids, xanthophylls, polyphenolic, oligomeric procyanidins with strong antioxidant capability[3-11]. Lotus rhizome has multiple functional characteristics such as anti-inflammatory, antioxidative, antidiabetic and anti-hypercholesterolemia activities[12]. It could be consumed via roasting, cooking or frying. Frying creates specific flavor, aroma and texture to foodstuffs due to different physico-chemical changes such as moisture reduction, oil uptake, starch gelatinization, protein denaturation, surface browning and crispness. This method also improved palatability, digestion and stable shelf-life. Recently, consumers have paid much more attention to low fat food owing to health concerns[13-14]. People have also been paid attention to decomposition of phytochemical compounds and generation of harmful elements originated from the frying process[15]. Hydrocolloids are implemented on a variety of food production such as thickener, emulsifier, stabilizer to create a proper layer having desirable barrier attribute, low oil absorption as well as durable mechanical elasticity[16-17]. From that approach, product's shelf-life would be extended remarkably. It also significantly contributed to overall acceptance of fried products. Carrageenan which is derived from seaweed is widely applied for textural functionality, particularly for gelling and viscosity[18]. Carboxymethyl cellulose is a cellulose derivative having the possibility to link water molecules within the system[15]. Sodium alginate has block structure capable of cross-link and bind[19]. Lotus rhizomes have revealed a very good potential to be explored as food supplements or pharmaceutical products to improve human health[20]. It has high economic value due to its crispness, attractive white colour and abundant nutrients. Therefore, purposes of our study focused on the effectiveness of various hydrocolloids such as carrageenan, carboxymethyl cellulose, sodium alginate as edible coating to enhance the quality of fried lotus rhizome with respect to moisture reduction, oil uptake and overall acceptance.

2. MATERIAL AND METHOD

2.1 Material

Lotus rhizomes with voucher number 20070815 were obtained from Dong Thap province, Vietnam. After collection, they were brought to the laboratory for experiments. Carrageenan, carboxymethyl cellulose, alginatewere all supplied from Rainbow Trading Co. Ltd., Vietnam. Sunflower oil was purchased from the local market.

2.2 Coating of the lotus rhizome

Lotus rhizomes were sliced into pieces (3 mm depth). These pieces were individually coated by different coating agents such as carrageenan, carboxymethyl cellulose, alginate in different concentrations (0.75%, 1.0%, 1.25%, 1.5% w/v). They were weighed (0.75, 1.0, 1.25, 1.5 g) and dissolved in 100 ml of distilled water. Glycerol was added at 0.5% w/v to these solutions as a plasticizer. Lotus rhizomes were dipped in these blends one by one in 30 seconds and then cooled at ambient temperature to create the coating films on sample surface[18]. The coated lotus rhizome pieces were then fried in sunflower oil at 190 °C for 2.5 minutes. The full fried pieces were drained off excessive oil by air cooling at ambient temperature. All treated samples were then stored in a dry cool place before analyzing moisture reduction (% w/v), oil uptake (% w/v) and overall acceptance[13, 14, 18].

2.3 Physico-chemical, sensory analysis

Moisture reduction (%) was measured by comparison of the initial weight before frying and final weight after frying by using moisture analyzer. Oil uptake (%) was evaluated by Soxhlet extraction protocol[18]. Oil uptake ratio of the fried coated lotus rhizomes was defined as the weight ratio between the amount of oil uptake and the amount of water removed. The oil uptake ratio (OUR) was calculated from the moisture content of the raw and fried sample and the oil content of the fried sample using the formula:

$$OUR = \frac{O_f(\%)}{[M_r - M_f](\%)}$$

Where,
OUR: Oil uptake ratio (%)
Of (%): Oil content of the fried sample
Mr (%): Moisture content of the raw sample
Mf (%): Moisture content of the fried sample

Overall acceptance was evaluated by a group of panelists using a 9 point-Hedonic scale[1].

3. STATISTICAL ANALYSIS

The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Statgraphics Centurion version XVI. The data were presented as mean±standard deviation. Probability value of less than 0.05 was considered as statistically significant[2].

4. RESULTS AND DISCUSSION

4.1 Moisture reduction

One of major concerns in the fried lotus rhizome is the oil uptake. In deep-frying, the moisture in the crust evaporates and moves out of the food surface, whereas oil enters the product core[21]. Hydrocolloids are affected to the pickup of a coated product by interacting to viscosity, surface adherence and therefore reducing material loss [22-23]. Moisture reduction is a main parameter to evaluate fried products suitable to consumption related to the freshness and shelf-life for the

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preservation. Moisture reduction (%) in fried lotus rhizome was significantly affected by a kind of hydrocolloids as well as their concentrations (see table 1). Carboxymethyl cellulose at 1.5% as edible coating revealed the highest moisture reduction (88.82%). However there was not significant difference in moisture reduction (%) between 1.25% and 1.5% of carboxymethyl cellulose coating so the value of carboxymethyl cellulose 1.25% was adequate. In another report, the most effective level of fat reduction on fried potato chip-based pellets was found using 4% carrageenan[18]. Using edible coating for frying potato strips increased moisture content of the products[24-25]. Increased moisture content due to coating maybe a result of the barrier of coating properties that prevent moisture loss during frying[26].

Table 1. Moisture reduction (%) of the fried lotus rhizome coated by hydrocolloids

Hydrocolloids	0.75%	1.0%	1.25%	1.5%
Carrageenan	84.29±0.02^{b}	84.97±0.04^{ab}	85.13±0.00^{a}	85.18±0.02^{a}
Carboxymethyl cellulose	88.03±0.00^{b}	87.21±0.02^{ab}	88.79±0.01^{a}	88.82±0.01^{a}
Alginate	86.14±0.03^{b}	86.74±0.00^{ab}	87.03±0.00^{a}	87.06±0.03^{a}

Note: the values were expressed as the mean of three repetitions; the different superscripts (a, b as denoted above) indicate the significant difference (α = 5%).

4.2 *Oil absorption*

In deep frying, cell wall of lotus rhizome gets bursted and damaged, consequently formation of capillary holes and voids appeared. Oil gets absorbed into the pores or the voids in the porous material. Edible coating on food surface prior to deep-fat frying is a popular manipulation to limit oil absorption into food core relating to quality and sensory factors of fried commodities[27-30]. Oil absorption (%) was strongly influenced by hydrocolloids as well as their concentrations (see table 2). The lowest oil uptake (14.84%) in the fried samples was recorded when coated with 1.5% of carboxymethyl cellulose. However there was not significant difference in oil uptake (%) between 1.25% and 1.5% of carboxymethyl cellulose coating so the value of carboxymethyl cellulose 1.25% was appropriate. The oil content of products was affected by initial moisture content and particle size distribution. Higher initial moisture content and small particle size resulted in higher residual oil content, in addition, the ratio of residual oil content to water removed was independent of frying oil temperature[31].

Table 2. Oil absorption (%) of the fried lotus rhizome coated by hydrocolloids

Hydrocolloids	0.75%	1.0%	1.25%	1.5%
Carrageenan	18.46±0.03^{a}	18.03±0.02^{ab}	17.75±0.03^{ab}	17.36±0.02^{b}
Carboxymethyl cellulose	15.89±0.00^{a}	15.42±0.00^{ab}	15.06±0.00^{ab}	14.84±0.00^{b}
Alginate	16.92±0.02^{a}	16.45±0.01^{ab}	16.03±0.02^{ab}	15.77±0.01^{b}

Note: the values were expressed as the mean of three repetitions; the different superscripts (a, b as denoted above) indicate the significant difference (α = 5%).

4.3 *Overall acceptance*

Fat frying was widely applied in the food processing as consumers prefer the taste, appearance and texture[18]. In deep-frying, interactions between oil and material created various physico-chemical and sensory changes[32]. Sensory evaluation on the fried lotus rhizome was executed with respect to overall appearance, color, crispness and aroma. The highest organoleptic value (8.45) was observed at the fried lotus rhizome coated by 1.5% carboxymethyl cellulose (see table 3). However there was not significant difference in overall acceptance between 1.25% and 1.5% of carboxymethyl cellulose coating so the value of carboxymethyl cellulose 1.25% was selected. In another report, the efficacy of various frying temperatures (180, 190 and 200°C, for 15-20 sec) on the overall qualities such as proximate composition, texture and sensory of lotus rhizome chips were verified. Organoleptic values showed high acceptability for chips manufactured by frying at 200 °C[33]. Lotus rhizome powder could be applied as an effective natural ingredient for the renovation of healthier and functional foodstuff[34].

Table 3. Overall acceptance of the fried lotus rhizome coated by hydrocolloids

Hydrocolloids	0.75%	1.0%	1.25%	1.5%
Carrageenan	7.15±0.00^{b}	7.34±0.03^{ab}	7.59±0.01^{a}	7.61±0.02^{a}
Carboxymethyl cellulose	7.78±0.03^{b}	8.04±0.00^{ab}	8.42±0.03^{a}	8.45±0.02^{a}
Alginate	7.36±0.01^{b}	7.73±0.00^{ab}	7.96±0.02^{a}	8.00±0.01^{a}

Note: the values were expressed as the mean of three repetitions; the different superscripts (a, b as denoted above) indicate the significant difference (α = 5%).

Carrageenan and other coatings produce a stable food with a crisp exterior and a soft, tender interior[35]. Oil uptake during frying should be considered as the fat content of a product affects its flavor, odor and general organoleptic properties[36]. Hydrocolloid coatings were invisible and have no negative influence on the sensory attributes of fried food[37].

5. CONCLUSION

Oil absorption is one of the most important quality parameters of fried food**.** Consumers prefer fried products with low amounts of oil uptake due to physico-chemical attributes as well as health problems. Lotus rhizome contains several biological active compounds such as polyphenolic compounds and oligomeric procyanidins. It has good nutritional value together with phytochemical attributes especially phenolic compounds known as natural antioxidants that could be utilized as a functional ingredient in food industry. The main purpose of this research was to produce a new healthy fried chips with low oil uptake by using lotus rhizome coated with hydrocolloids. From deep processing, post-harvest losses of lotus rhizome would be decreased; income of rural farmers would be improved and they would get more chances to inherit profit from cultivating and processing this valuable crop in our community.

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7. CONFLICT OF INTEREST

Conflict of interest declared none.

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