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Edible coatings from sunflower head pectin to reduce lipid uptake in fried potato chips

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ABSTRACT

Edible coatings from low-methoxyl sunflower head pectin (SFHP) was prepared to reduce lipid uptake in fried potato chips. Formation of pectin coatings were induced by calcium cations within several seconds prior to frying. Effects of pectin concentration and $CaCl_2$ concentration on reduction of lipid content in coatings were investigated. Experimental results indicated that the coating prepared with 1.0% (w/v) SFHP and 0.05 mol/L $CaCl_2$ can reduce the lipid uptake by about 30% in comparison with the uncoated chips. This result was close to that of coating prepared from 3.0% (w/v) methyl cellulose (MC). Texture analysis suggested that $CaCl_2$ concentration showed significant influence on the brittleness and crispiness of 1.0% (w/v) SFHP-coated chips. During frying, SFHP-coated chips presented weak non-enzymatic browning resulting in a slight color change in comparison with uncoated chips. In the case of MC-coated chips, the L^* was significantly decreased and b^* was considerably shifted towards yellow leading to dark-yellow appearance. Sensory analysis was performed using a 9-point hedonic scale. SFHP-coated chips had the scores lower than that of uncoated chips but higher than that of MC-coated chips.

1. Introduction

Fried foods can contain significant amounts of lipids, reaching in 15–30% of the total food by weight (USDA-ARS, 2000). This ensures a high level of satiety, but also poses a risk since saturated fats and trans-fat have become associated with obesity and coronary heart diseases (Rosenheck, 2008; Saguy & Dana, 2003). Fried potato chips are popular fast-foods (snacks) in many countries. Deep-frying of potato chips is commonly conducted at 150–190 °C for several minutes (Krokida, Oreopoulou, & Maroulis, 2000). During frying, moisture within chips is evaporated to move outside and oil penetration is confined to the outer surface (Mellema, 2003). Moisture evaporation will also lead to shrinkage and development of surface porosity and roughness, which highly affect the mouthfeeling. Maillard reactions occurred in the crust not only brown chips' color, but also produce typical frying flavors (Whitfield & Mottram, 1992).

Many researches have employed edible coatings prepared from food hydrocolloids to reduce lipid content in fried potato chips, such as cellulose derivatives, gellan gum, arabic gum, alginate and carrageenan, with acclaimed oil reduction effect ranging from 20% to 90% (Falguera, Quintero, Jiménez, Muñoz, & Ibarz, 2011; García, Ferrero, Bértola, Martino, & Zaritzky, 2002; Garmakhany, Mirzaei, Nejad, & Maghsudlo, 2008; Williams & Mittal, 1999). With strong water holding capacity and high firmness these coatings can effectively inhibit moisture evaporation therefore reducing lipid uptake (Pinthus, Weinberg, & Saguy, 1992, 1995b).

In comparison with methyl cellulose (MC), pectin has been relatively less used to prepare edible coating for fried chips (Albert & Mittal, 2002; Debeauforta, Quezada-Galloa, & Voilley, 1998; Freitas et al., 2009). Low methoxyl pectin (LMP) with a degree of esterification (DE) of 20–30% can quickly gel induced by calcium cations (Axelos & Thibault, 1991). Thus, the formation mechanism of LMP coating based on the coordinative reaction between pectin and calcium is different from the thermal-inducing mechanism of cellulose derivatives. Furthermore, pectin gels from various sources with different physiochemical properties (Capel, Nicolai, Durand,

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Boulenguer, & Langendorff, 2006; Lootens et al., 2003; Picout, Richardson, Rolin, Abeysekera, & Morris, 2000) can present different effect in reducing lipid content and modifying the texture and sensory attributes of fried potato chips.

In our previous work, physicochemical properties of a natural LMP extracted from sunflower head (SFHP) has been investigated (Hua, Wang, Yang, Kang, & Zhang, 2015; Wang, Hua, Yang, Kang, & Zhang, 2014). In the presented study, SFHP was used to prepare edible coatings for fried potato chips. In China and many countries, the fresh fried chips sold as the fast foods (snacks) are made from frozen chips by a short-time frying (170–180 °C, 3–4 min). For this reason, commercial frozen chips, which is a pre-fried (170–180 °C, 30–40 s) product containing 4–6% (w/w) lipids, was used as raw material in this study. Effects of calcium concentration and pectin concentration on lipid uptake reduction were investigated. The texture analysis, chromatism measurement and sensory evaluation of SFHP-coated chips were performed using MC-coated chips as contrast. The aim of this study is to discuss the effect of such LMP coating on chips' quality and to present a technological application of LMP in preparing low-fat fried potato chips in fast foods restaurants.

2. Materials and methods

2.1. Materials

Sunflower head pectin (SFHP) was extracted from oilseed sunflower harvested in Xinjiang (China) by our group (Wang et al., 2014). The obtained SFHP had a DE of 31.7 ± 0.5%, galacturonic acid content of 86.0 ± 0.9% and DA_m (degree of amidation) of 9.66 ± 0.15%. The weight-average molecular weight (M_w) and number-average molecular weight (M_n) of SFHP was 605.6 kDa and 111.0 kDa, respectively.

Commercial frozen chips (45 mm × 10 mm × 10 mm, specified lipid content 6%, w/w) were purchased from American Lorain Corporation (Shandong, China). Chips of uniform size were used to minimize the errors caused by chips weight. Commercial sunflower seed oil used in frying was purchased from local market. All the analytical-grade chemicals were purchased from Sinopharm Chemical Reagent (Shanghai, China) and used without further purification.

2.2. Preparation of SFHP-coated chips

Frozen chips (10–20 pieces) were fully submerged in specific SFHP solution (1.0%, 2.0%, 3.0%, w/v) for 5 s and subsequently in specific $CaCl_2$ solution (0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5 mol/L) for 3 s. After draining off the excessive liquid, chips were fried using an electrical fryer (SZ-6AX2, KSBS-Fryer, Guangdong, China) at 170 °C for 3 min. Fresh sunflower seed oil was used for each treatment and maintained at the processing temperature for 1 h. The proportion of food to oil was constantly 1:20 and the chips were fully submerged in oil during frying. The products were subsequently shaken in aluminum basket to drain off the excessive oil. To prepare the pre-dried SFHP-coated product, the chips was dried at 45 °C for 4 h in an hot-air oven (BAO-80A, STIK, Shanghai, China) before frying.

2.3. Preparation of MC-coated chips

Chips were fully submerged in specific MC solution (1.0%, 2.0%, 3.0%, w/v) for 5 s. After draining off the excessive liquid, the chips were subjected to the same frying process that has been applied to SFHP-coated chips. The pre-dried processing of MC-coated chips were also the same to that of SFHP-coated products.

2.4. Determination of moisture content

Moisture content was determined using desiccation method according to the procedure of P.R.C national standard GB 5009.3-2010. The fried chips were divided into three groups. Each group was placed in a metal dish and dried in a forced-air oven (BAO-80A, STIK, Shanghai, China) at 105 °C to constant weight and cooled in a desiccator. For each group, the moisture content (C_w, w/w) can be written as:

$$C_W(\%) = \frac{m_0 - m_s}{m_0} \times 100 \quad (1)$$

where the subscript *0* and *S* denotes the mass of the fried chips before and after drying, respectively.

2.5. Determination of lipid content

The samples fully dried in moisture determination were subsequently subjected to lipid determination. Lipid content was measured using Soxhlet extraction method described by P.R.C national standard GB/T 5009.6-2003. In a typical procedure, 3.0 g sample (ground to pass over 40-mesh screen) was placed inside a thimble made from thick filter paper, which was loaded into the main chamber of the Soxhlet extractor. A heated 250 mL round-bottom flask, with magnetic stirring, contained 150 mL ether at 60 °C. After refluxing for 12 h, the ether solution was concentrated under vacuum until 1–2 mL left in a rotary evaporator (R10, IKA, Guangzhou, China). The obtained raw lipid was subsequently dried at 105 °C to constant weight and cooled in a desiccator. The lipid content (C_L, w/w) can be expressed as:

$$C_L(\%) = \frac{m_L}{m_0} \times 100 \quad (2)$$

where the subscript *L* and *0* represents the lipid mass and the sample mass, respectively.

2.6. Texture analysis

After draining off the excessive oil, the chips were allowed to cool down to ambient temperature prior to texture analysis. The texture measurement was performed on a texture analyzer (TA-XT Plus, Texture Technologies, USA). A 2 mm cylinder stainless probe (Part Code. P/2) was used to measure force in compression mode, which depicts the force–distance plot of fried potato chips. Measurement settings: test speed = 1 mm/s, pre-test speed = 2 mm/s, post-test speed = 10 mm/s, distance = 5 mm, trigger force = 20 g.

2.7. Chromatism analysis

A digital colorimeter (CR-400, Minolta-Konica Sensing Inc., Osaka, Japan) was used to measure the skin color of fried chips. The CIE Lab L* (lightness), a* (redness) and b* (yellowness) color scales were used. Triplicate readings were carried out at 25 °C on each three equidistant locations of each chip (for both sides) and the mean value was recorded. Color difference (Hunter ΔE) is expressed as:

$$\Delta E = \sqrt{\left(L^* - L_c^*\right)^2 + \left(a^* - a_c^*\right)^2 + \left(b^* - b_c^*\right)^2} \quad \text{(Eq.3)}$$

where the subscript *c* represents the L*, a*, and b* values of the coated chips. The color of uncoated chips was designated as a reference.