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Reduction of the fat content of battered and breaded fish balls during deep-fat frying using fermented bamboo shoot dietary fiber

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A B S T R A C T

The reduction of fat absorption during deep-fat frying of battered and breaded fish balls (BBFBs) was investigated using bamboo shoot dietary fiber (BSDF). BBFBs were prepared with 0–10% BSDF treatments, fried at 170 °C (50 s) followed by 190 °C (10 s), then evaluated for fat absorption, textural characteristics, and other quality parameters. The addition of 6% BSDF in the batter improved sensory quality of fried BBFBs (higher brightness and a golden-yellow crust); fat content of the crust and the core of fried BBFBs decreased from 25.5% and 2.4% to 17.7% and 1.3%, respectively. Hardness and chewiness of the crust and the core of fried BBFBs were also improved after adding BSDF to the batter. Microscopic analysis revealed more a compact crust structure and smaller pores inside the core that were more uniformly distributed when compared to fried BBFBs without BSDF. Moreover, of all the treatments, the addition of 6% BSDF produced the lowest oil penetration into fried BBFBs. These findings proved that BSDF added to the batter can significantly reduce fat absorption allowing low-fat fried BBFBs production.

1. Introduction

Deep fried battered and breaded foods are popular food items widely enjoyed by consumers. However, over-ingestion of these products, in some cases with fat content up to one-third of the total food product by weight, can cause obesity and various cardiovascular diseases (Mellema, 2003). Numerous techniques for lowering fat content in fried foods have been explored, including the creation of an edible physical barrier (film) on deep-fat fried foods, alteration of the surface of the foods, control of the polarity of frying oil through frequent replacement with fresh oil, and modification of the frying process through adjustment of frying temperature, time or method (Brannan, Myers, & Herrick, 2013; Myers & Brannan, 2012). In particular, the formation of edible films as barriers on deep-fat frying battered and breaded foods has been extensively investigated because of their efficacy as inhibitors of fat absorption. Moreover, the physical and mechanical properties of fried battered and breaded foods can be manipulated depending on the physicochemical nature of the film generated underneath the layer of the breading material (Brannan et al., 2014).

Previous research on film barriers as a means to inhibit fat absorption during deep-fat frying has primarily focused on the selection of the appropriate type of proteins and hydrocolloids. Examples are animal proteins (milk proteins, extracted myofibrillar proteins, gelatin, collagen, and egg albumin), plant proteins (barley, corn, sorghum, soy, and wheat), cellulose derivatives (hydroxymethyl, hydroxypropyl, and carboxymethyl gums), and other polysaccharide gums (xanthan, Arabicgum, carrageenan, and guar gums) (Chen, Chen, Chao, & Lin, 2009; Kang & Chen, 2015; Mah & Brannan, 2009; Mah, Price, & Brannan, 2008). The mechanisms inhibiting fat absorption through proteins and hydrocolloids have been reported to account for film formation, increasing surface hydrophilicity, and thermally induced gel formation (Varela & Fiszman, 2011). However, these techniques through proteins and hydro -colloids as barriers on deep-fat frying battered and breaded

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foods require an unrealistically long drying time on an industrial scale, although most of them are successful at inhibiting fat absorption during deep-fat frying (Brannan et al., 2013). Therefore, some alternative approaches have been tried.

Brannan et al. (2013) found that the levels of oat and corn fiber in the egg white dips could affect the inhibition of fat absorption during deep-fat frying. According to Ang, Miller, and Blais (1991), commercially available batter mixes added with cellulose fiber enabled a reduction of fat absorption by 30% in battered chicken strips and 35% in battered fish fillets.

Another potential anti-oil absorption ingredient is bamboo shoot dietary fiber (BSDF). Bamboo shoots are budding sprouts wrapped inside a bamboo sheath and frequently used as a common food material to produce processed foods including poached or fermented bamboo shoot can, dried bamboo shoots, and bamboo shoot drinks in many Asian countries (Badwaik, Borah, & Deka, 2014; Chen et al., 2013; Tamang & Sarkar, 1996). Bamboo shoots have also become popular imported products in many other countries where bamboo shoots are valued for their rich content in dietary fiber, high-quality protein, and vitamins and their physiological benefits through improving digestion, relieving sweating and hypertension, and preventing cardiovascular diseases (Choudhury, Sahu, & Sharma, 2011; Park & Jhon, 2010). Bamboo shoots and a great many of by-products formed during processing are fermented to produce BSDF. This unique dietary fiber has been incorporated into biscuits, pork nuggets, and other foods because of its enhancement of flavor and aroma, providing bio-nutrient and minerals, and improving the food quality and shelf-life (Thomas, Jebin, Barman, & Das, 2014; Xie, Li, Hu, Zhong, & Jiang, 2000).

To the authors' knowledge, there is no published report on BSDF being added to the batter to produce low-fat battered and breaded fish balls (BBFBs). Therefore, the objective of this study was to reduce the fat content of fried BBFBs through adding BSDF to the batter. The effect of BSDF on fat content, colour, texture, microstructure, and fat absorption of fried BBFBs was also investigated through analysis of colorimeter, texture analyzer, scattering scanning electron microscope (SEM), and the frying experiment in Sudan red dyed oil.

2. Materials and methods

2.1. Materials

Frozen silver carp surimi was donated by Wuhan Liangzihu Fisheries Group Co., LTD (Wuhan, China). BSDF containing 14.5% (wt%, dw) soluble and 72.6% (wt%, dw) insoluble fibers was donated by Hubei Ruifa Biological Engineering Co., LTD (Chongyang, China). The BSDF powder was a product that passed through a 100 mesh sieve. Plain wheat flour was obtained from Wuhan Taiyanghang Food Co., LTD (Wuhan, China). Glutinous rice starch containing 88.1% starch (wt%, dw) was acquired from the Grain Science & Engineering Laboratory of the Wuhan Polytechnic University (Wuhan, China). Egg white powder was purchased from Egg Development Co., LTD (Dalian, China). Baking powder was obtained from Angel Yeast Co., LTD (Yichang, China). Breadcrumb with <2 mm particle size was from Wuxi Jinhuanghua Food Co., LTD (Wuxi, China). Soybean oil was purchased from COFCO Corporation (Beijing, China). Sudan Red B was purchased from Shanghai Hendalao Biological Co., LTD (Shanghai, China).

2.2. Preparation of BBFBs

BSDF powder at different proportions (0, 2, 4, 6, 8, and 10%, wt%) was mixed into the basic batter power (50 g plain wheat flour, 30 g glutinous rice flour, 10 g egg white powder, 1 g baking powder, and 1 g salt) to produce 6 breading treatments. Ninety-gram deionized water was then added with stirring to form homogeneous pastes (batters). Frozen silver carp surimi was thawed at room temperature and diced into small pieces. To prepare fish balls, 200 g of silver carp surimi was finely chopped in a Model HR 7633 chopper mixer (Philips Household Appliances Co., LTD, Zhuhai, China) operated at 1600 rpm for 5 min, then, 3 g of salt was added and the chopping was continued for 5 min at the speed of 2000 rpm. The chopped surimi was made into fish balls (10 ± 1 g) by hand. They were immediately immersed into the batters for 10 s, after which the fish balls were taken out and placed on a stainless steel tray for about 15 s. The immersion process was repeated one additional time, and the excess coating was allowed to drain off. The fish balls were subsequently rolled in breadcrumbs until a uniform coverage was attained.

2.3. The frying process

In batches of eight fish balls each, BBFBs were fried in soybean oil at 170 °C using a deep fryer (YZ-3032-BC, Guangdong Youtian Household Appliances Co., LTD, Fushan, China) for 50 s, then allowed to cool for 1 min. When the temperature of the oil rose to 190 °C, BBFBs were placed back into the heated oil and fried for 10 s. Fried BBFBs were allowed to cool at room temperature for 20 min, then subjected to colour evaluation and textural analysis. The tested samples were subsequently processed for moisture and fat analysis.

2.4. Moisture and fat analysis

Moisture and fat contents of the crust and the core of fried BBFBs were measured according to the method given in a published report (Brannan et al., 2013) with slight modifications. After colour and texture analysis, the crust and the core of fried BBFBs were finely ground using a stainless steel scissor until ostensibly homogeneous. The moisture content analysis of the crust and the core of fried BBFBs was performed by following vaccum oven method obtained gravi -metrically after heating overnight at 105 °C (No. 934.01, AOAC, 1996). The final moisture content on dry basis was calculated by taking the difference between the wet and dry sample weights. The fat content analysis was measured via Soxhlet extraction method (No.991.36, AOAC, 1996).

2.5. Instrumental surface colour analysis

The colours of the crust and the core were determined using a colorimeter (WSC-S, Shanghai Precision Scientific Instrument Co., LTD, Shanghai, China). Firstly, the colour parameters of fried BBFBs were measured by putting them in front of the camera lens closely. Secondly, after the crust was removed from fried BBFBs and the core was cut into half, then the colour parameters of the core were measured using the same operating procedures. The colour measurements were taken 10–20 min after fried BBFBs were removed from the fryer. Measurements were performed in triplicate. The CIE Lab scale was used, where L^*, a^*, and b^* values indicated white (0) to black (100), red (+) to green (−), and yellow (+) to blue (−), respectively (Carlo et al., 2014).

2.6. Instrumental texture analysis

Hardness and chewiness of the crust and the core of fried BBFBs were separately measured according to Brannan et al. (2013) with slight modifications. Immediately following colour measurement, texture analysis was performed using a Ta-XT2i texture analyzer (Texture Technologies Corp., Scarsdale NY, USA) with a stainless