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Effects of protein enrichment on the properties of rice flour based gluten-free pasta

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A B S T R A C T

Manufacturers have long complained about gluten-free pasta for its apparent low cooking properties and reduced nutritional value. Proteins are not only bio-polymer that can improve the quality of a product, but they are also an essential nutrient for human health. Therefore, it was proposed to develop a multi-sourced protein enriched gluten-free pasta. The whey protein concentrate (WP) enriched pasta demonstrated the shortest optimal cooking time at 4.3 min. The enrichment of 9% (w/w) egg albumen (EB) displayed the greatest capacity for preventing structure disintegration with the lowest cooking loss of 4.38–4.63% ($P < 0.05$), whereas rice bran protein concentrate (RBPC) induced the highest cooking loss ($P < 0.05$). Enrichment with 6% soy protein concentrate (SP) provided similar L^* values with a commercial. Moreover, the 9% EB enrichment clearly affected to pasta structure as the pasta firmness improved up to 72.25%. The protein networks around the starch granules were observed to be enriched with EB and WP, whereas the pasta enriched with RBPC produced a cracked and non-continuous surface. Among the four sources of protein tested, EB had the highest potential for improving cooking properties of rice flour based gluten-free pasta.

1. Introduction

Pasta is a simple staple food product because of its palatable taste, cooking convenience, and affordability. It is generally prepared from only two ingredients, which are wheat flour and/or semolina, and water. Gluten consists of gliadin and glutenin, which is mainly responsible for elasticity and chewability (*al dente*) of pasta. Gluten is considered to be the most significant factor that directly affects cooking properties for pasta (Sozer, 2009). The high quality of pasta is mainly due to its low cooking loss, low stickiness, and firm structure. However, some people who suffer from celiac disease (CD) must avoid consuming products containing gluten, which can cause damage in the small intestine and may affect absorption of important nutrients (Mirhosseini et al., 2015). Thus, gluten-free pasta has become a high demand commercial product, mostly from those with CD.

Rice flour is recommended for use in gluten-free products processing instead of wheat flour because it possesses no gluten. It also has a bland taste and white colour, and it is highly digestible with hypoallergenic properties (Fabian & Ju, 2011). The absence of gluten results in technological and quality problems because rice flour is unable to form a cohesive dough structure (Heo, Jeon, & Lee, 2014). Therefore, replacing the gluten network to produce high quality gluten-free pasta is a major technological challenge. However, it is possible by choosing suitable formulations and recipes using the correct amount of proteins, hydrocolloids, and moisture to achieve the desirable quality attributes (Larrosa, Lorenzo, Zaritzky, & Califano, 2016).

Nowadays, nutrition attributes and the use of food additives in food products are a growing concern for consumers. New natural substances that have high nutritional value and multifunctional properties are increasingly being considered and accepted. Proteins are commonly used as structuring agents in solid and semi-solid foods to enhance mechanical strength, textural properties, consistency, and stability of a final product (Sozer, 2009). Many types of proteins such as whey, bovine plasma, cowpea, and lupine proteins have been added to food products for improving texture and overall quality (Campbell, Euston, & Ahmed, 2016; Kittisuban,

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Ritthiruangdej, & Suphantharika, 2014; Rodriguez Furlán, Padilla, & Campderros, 2015). Recently, egg white powder, casein, lupin, and rice proteins has been added in gluten-free pasta/noodle (Larrosa et al., 2016; Mariotti, Iametti, Cappa, Rasmussen, & Lucisano, 2011; Sozer, 2009) in order to reduce cooking loss and to improve the textural properties. Among proteins proposed for development in gluten-free products, egg albumen (Larrosa et al., 2016; Marti et al., 2014; Phongthai, D'Amico, Schoenlechner, & Rawdkuen, 2016), whey protein (Marti et al., 2014; Susanna & Prabhasankar, 2013), and soy protein (Crockett, Ie, & Vodovotz, 2011) are most frequently studied although they contain allergens. Rice bran protein has been introduced and incorporated into several food products because it is hypoallergenic and has good functional properties. It is also a high quality protein (Fabian & Ju, 2011). Different protein sources display different functions for the final product. Some researchers have already reported on the effects of proteins on quality of gluten-free pasta/noodle, but their products were produced with various conditions, thus the results are not suitably comparable (Campbell et al., 2016; Larrosa et al., 2016; Sadeghi & Bhagya, 2008; Sozer, 2009). Since limited information is available, this research aimed to study the effects of different protein sources (egg albumen, rice bran protein concentrates, soy protein concentrates, and whey protein concentrates) on the cooking properties of rice flour based gluten-free pasta. Furthermore, the microstructure, protein patterns, and solubility were also investigated.

2. Materials and methods

2.1. Materials

Organic rice bran (Thai Jasmine rice, KDML 105) was supplied by Urmatt Ltd. (Chiang Rai, Thailand). Rice flour was obtained from StroblCaj. NaturmuehleGesmb.H (Linz-Ebelsberg, Austria). Egg albumen (EB, protein 74.66 ± 0.79%dm) was purchased from Enthoven-Bouwhuis Eiproducten B.V. (Raalte, Netherlands). Whey protein concentrates (WP, protein 75.42 ± 0.54%dm) were procured from Trec Nutrition Sp.zo.o. (Gdynia, Poland), and soy protein concentrates (SP, protein 81.09 ± 0.26%dm) from Olimp Laboratories Sp.zo.o. (Debica, Poland). An emulsifier (distilled monoglyceride, Dimodan) was procured from Danisco® (Copenhegen, Denmark).

2.2. Preparation of rice bran protein concentrate

Rice bran protein concentrate was prepared according to the method described in previous work of Phongthai, D'Amico et al. (2016). The rice bran protein concentrate comprised of 68.07 ± 0.54% protein content.

2.3. Production of gluten-free pasta

The basic recipe of gluten-free pasta includes rice flour, 1% emulsifier (based on rice flour content), and 32% moisture content (based on total content). This basic recipe was enriched with 6% and 9% proteins including EB, RBPC, SP and WP (based on rice flour content and protein content). All dry ingredients were mixed at a speed of 1 for 2 min using a Kitchen Aid Mixer (KPM5O, St. Joseph, MI, USA), and then water was added slowly. Kneading continued for 15 min to achieve a homogeneous dough before extruding the pasta with a laboratory-scale pasta press (P3, La Monferrina Co., Castell'Alfero, Italy) with a band pasta (*tagliatelle*) die. The fresh pasta was cut into 10 cm strips and dried in a hot air oven at 60 °C for 10–12 h. A total amount of 400 g of each recipe was prepared in duplicate.

2.4. Determination of gluten-free pasta properties

2.4.1. Optimal cooking time (OCT)

The OCT for the pasta samples were determined by using the Approved AACC Method 66-50 (AACC, 2000). The dry pasta samples were cooked in boiling water, and the OCT was monitored during cooking until the white core of the pasta samples disappeared when squeezed between two glass plates. Measurements were performed in triplicate in two independent experiments ($n = 6$).

2.4.2. Cooking properties

The cooking loss and water absorption were measured according to the method of Heo et al. (2014) and Marti, Caramanico, Bottega, and Pagani (2013) with some modifications. 10 g of pasta samples were cooked in 250 mL-boiling water for their OCT, and then they were slowly drained for 5 min. The weight of the cooked pasta samples was recorded. The cooking water and cooked pasta samples were collected and dried to a constant weight in a hot air oven at 105 °C. Three measurements were taken for each sample ($n = 6$). The cooking properties in terms of cooking loss (%) and water absorption (%) were calculated by the following equations:

Cooking loss (%) = [(Weight of cooking water after drying)/(Weight of uncooked pasta)] × 100

Water absorption (%) = [(Weight of cooked pasta − Weight of uncooked pasta)/(Weight of uncooked pasta)] × 100

2.4.3. Colour

The colour of the uncooked pasta samples were measured by using a DigiEye System (VeriVide Limited, UK). The controlled illumination cabinet was used to take high resolution images of the pasta. The colour parameters (L^*, a^*, and b^*) were interpreted according to the CIE LAB definition by DigiPix software. The experiment was carried out in triplicate for each sample ($n = 6$).

2.4.4. Firmness

The firmness of the cooked pasta samples were investigated by using a Texture Analyzer (TA-XT2i, Stable Micro Systems™ Co., Godalming, UK) according to Approved AACC Method 66-50 (AACC, 2000). A single band of pasta sample was placed in the centre of the measuring area and cut with a light knife blade attachment (thickness 1 mm). Test parameters were 1 mm/s pre-test speed, 0.1 mm/s test speed, 10 mm/s post-test speed; distance was adjusted to a maximum of 1 mm, and 0.020 N was fixed as the trigger force. The maximum force value referred to pasta firmness. The measurement of each recipe was performed in 6 replications ($n = 12$).

2.4.5. Protein solubility

The determination of protein solubility followed the method described by D'Amico et al. (2015). The dry uncooked pasta samples were milled in a kitchen blender and mixed with phosphate buffer containing 8 mol/L urea. The mixtures were then centrifuged at 2500×*g* for 30 min. The protein content in the solutions was analyzed by using the Bradford method (Bradford, 1976). The absorbance was measured by a photometer (NanoQuant infinite M299 PRO, Tecan Group Ltd., Männedorf, Switzerland) at 595 nm. Bovine serum albumin was used as a protein standard. The determination of each recipe was done in triplicate.