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Quality improvement of rice noodle restructured with rice protein isolate and transglutaminase

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ABSTRACT

In an effort to improve the properties of rice dough and quality of gluten-free rice noodle, transglutaminase (TGase) and rice protein isolate (RPI) were applied to rice noodle making process. The storage and loss moduli of rice dough increased by TGase treatment, whereas they decreased with RPI supplementation. The combined treatment of RPI + TGase on rice dough fully recovered the reduced moduli caused by RPI only supplementation to control level, and increased most of viscosity parameters of rice noodle in RVA analysis. This additional treatment of TGase also increased development time, and maximum and peak torques of RPI-supplemented rice dough in Mixolab® analysis. Cooking loss and water turbidity of rice noodle decreased by 54.8% and 66.6%, respectively, after TGase + RPI treatment. Scanning electron micrographs showed cracked noodle surface became smoothed with TGase treatment, which was more obvious with RPI + TGase treatment. These results suggest RPI + TGase treatment could improve the quality of rice noodle without the use of gluten-like ingredients.

1. Introduction

In Asian countries, many varieties of noodles are widely consumed. They are traditionally made from rice, buckwheat, and starches of mung bean and potato and in recent years, they became popular in western countries in recent years (Bin Xiao, 2008). The most critical reason for the consumption could be the needs for gluten-free products for the increasing population of individuals with celiac disease. Celiac disease is a lifelong autoimmune disorder that is passed on genetically triggered by the ingestion of proteins of wheat, rye, and barley in genetically susceptible individuals which comprises approximately 1% of the worldwide population (Renzetti, Behr, Vogel, & Arendt, 2012). Currently, the withdrawal of gluten from the diet is the only way to avoid the related symptoms and the needs for good quality gluten-free products have brought about the interest of developing gluten-free products.

Rice is regarded as one of the most appropriate cereal grains for producing gluten-free products owing to its benefits of high digestibility, hypoallergenic properties and so on (Marco & Rosell, 2008a). Rice is very widely consumed in Asia, and in this regard, rice noodles were eaten for long time in many Asian countries. Despite all the advantages, the viscoelastic quality of rice noodle solely depends on the properties of the starch component due to the poor network development of rice protein, accordingly, rice is often unable to meet the requirements for the noodle processing (Sandhu, Kaur, & Mukesh, 2010). For this reason, the addition of strengthening agents and specific treatments such as fermentation, hydrothermal, and enzyme treatments have been proposed to provide necessary network for processing of rice products (Yang & Tao, 2008; Hormdoka & Noomhorm, 2007; Gujral, Guardiol, Carbonell, & Rosell, 2003). Among them, cross-linking of rice protein using transglutaminase (TGase) showed the possibility of improving the functionality of rice proteins (Gujral & Rosell, 2004; Marco & Rosell, 2008a). TGase catalyses the reaction between an ε-amino group on protein bound lysine residues and a γ-carboxyamide group on protein-bound glutamine residues, leading to the covalent crosslinking of the proteins (Folk & Finlayson, 1977). TGase treatment enhanced the consistency and elasticity of brown rice batters and resulted in significant improvement of the textural quality of breads (Renzetti et al., 2012). Meanwhile, gluten-free products made of non-wheat cereals have very low protein content and lysine residues which TGase possibly utilises to make cross-links. Due to this, the reinforcement of rice products with protein is inevitable, and proteins from various sources, such as soybean, pea, egg albumin, and whey, have been applied in order to increase the reactivity of protein with TGase and to increase the nutritional value of gluten-free products as well (Gallagher, Kunkel, Gormley, & Arendt, 2003; Marco & Rosell, 2008a). However, these proteins have limitations when added to rice noodle production, due to their allergenic effects or low acceptability by consumer. In contrast to other proteins, *rice protein* can be an excellent source with high nutritional and health-related properties, such as well-bal-

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anced amino acid, hypocholesterolemic and hypolipidemic effects, and high anti-cancer activity (Xia et al., 2012). Although certain similarities have been found between the amino acid sequences of rice globulins and wheat glutenin subunits, rice storage proteins do not contain the toxic epitope responsible for celiac disease (Komatsu & Hirano, 1992). Moreover, recent researches revealed that RPI could be extracted from rice bran which is an inexpensive, underutilised milling co-product of rough rice (Tang, Hettiarachchy, Eswaranandam, & Crandall, 2003). In this study, rice flour was restructured by both enriching rice protein and treating with TGase and the effects of RPI supplementation and TGase treatment on the properties of the dough and noodle were investigated to demonstrate the possibility of producing high quality rice noodles without the use of any exogenous components other than rice.

2. Materials and methods

2.1. Materials

Commercial rice flour was obtained from the Sunssalnara Co., which was produced from *Choochung* cultivar grown in Ansung, Korea in 2009, and rice protein isolate (RPI) was a gift from CJ cheiljedang Co. (Seoul, Korea). Food-grade microbial TGase (Activa TGase) was provided by Ajinomoto Co. (Tokyo, Japan). All other reagents were of analytical grade.

2.2. Rice dough and noodle preparation

Rice flour (50.0 g) was mixed with NaCl (1.0 g) in distilled water (35.0 mL) for 10 min by using a Kitchen Aid mixer (St. Joseph, MI, USA) equipped with a paddle beater. After mixing, the dough was rounded and covered with plastic wrap, and rested at 40 °C for 2 h in a dry oven. The dough was passed through reduction rolls of a noodle machine (Bethel industry, BE-6200, Uijeongbu, Korea) to produce a uniform dough sheet. The roller gap was maintained at 0.2 cm for the last sheeting. The dough piece cut into 2-cm diameter round shape was used for the oscillatory measurements. In order to determine the quality rice noodle, the dough sheet was cut into 0.6 × 5 cm (width × length) strands. Rice flour was reconstituted by substituting 10% (w/w) of RPI. The TGase treatment on the dough was conducted by adding 1% (w/w) of TGase. The rice noodles were dried at 40 °C for 2 h using a dry oven, and then ground for the measurements of pasting and thermal properties.

2.3. Oscillatory measurements of rice dough

Dynamic rheological measurements of rice dough were performed on a controlled stress rheometer (AR1500ex, TA Instruments) with a 20-mm parallel plate (3-mm gap). The rim of the sample was coated with baseline oil in order to prevent evaporation during the measurements. All rheological measurements were performed at 30 °C. Frequency sweep tests were performed from 0.01 to 10 Hz to determine the storage modulus (G'), loss modulus (G''), and tangent delta ($\tan\delta$) as functions of frequency.

2.4. Thermomechanical property of rice dough

Mixing and pasting behaviours of rice flour dough were studied using a Mixolab analyzer (Chopin, Tripette et Renaud, Paris, France), which was capable of evaluating rheological properties of the flour. Mixolab analyzer measures (in real time) the torque (Nm) that is produced by the passage of dough between two kneading arms, thus allowing evaluation of physicochemical behaviour. The instrument analyses the quantity of protein network and starch behaviour during heating and cooling. For the assays, 43.16 g of rice flour was placed and mixed in the Mixolab analyzer bowl. After tempering the solids, the 31.84 mL of distilled water was added. Special attention was paid to the determination of the water absorption to ensure the complete hydration of all the components. Initially, the mixture was stayed for 8 min at 30 °C then temperature was increased at the rate of 4 °C/min until 90 °C; at this point, there was an 8-min holding period at 90 °C, followed by a temperature decrease of 4 °C/min until the mixture reached 50 °C, and finally 10 min of holding at 50 °C.

2.5. Pasting property of rice noodles

A Rapid Visco Analyzer (AR1500ex, TA Instruments, New Castle, DE, USA) was used to analyse pasting properties of the noodle samples. The noodles were dried in an air oven at 40 °C for 12 h, then ground to pass through 100-μm sieve. Three grams of ground rice noodle was dispersed into 25.0 mL of distilled water in an aluminum canister. The RVA curves were evaluated in terms of peak, final, and setback viscosities. Sample was held at 50 °C for 3 min for even distribution, heated to 95 °C in 7.5 min, and then held at 95 °C for 5 min. After that, it was cooled to 50 °C in 7.5 min, and then held at 50 °C for 2 min. The rotating speed was maintained at 160 rpm during the whole process.

2.6. Protein electrophoretic pattern of rice noodles

In order to extract proteins from rice noodle, 1.0 mL of a buffer containing 0.063 M tris-(hydroxymethyl) aminomethane (Tris–HCl, pH 6.8), 2% (w/v) SDS, 10% (v/v) glycerol, 3% (v/v) β-mercaptoethanol, and 0.01% (w/v) bromophenol blue was added to 50 mg each of untreated and TGase-treated, and 30 mg each of RPI-treated and RPI + TGase-treated ground rice noodles. Suspensions were vortexed for 2.5 h, heated in a boiling water bath for 5 min, and cooled at room temperature. Then they were centrifuged at 3000*g* for 5 min, and the proteins in the supernatants were loaded onto the well of gel slab. SDS-PAGE analysis was performed in 12% separating gel with 4% stacking gel (Marco, Perez, Leon & Rosell, 2008). Electrophoresis started at 80 V for stacking gel, and changed to 120 V for separating gel. A PageRuler™ prestained protein ladder (Fermentas, St. Leon-Rot, Germany) was used as a molecular weight marker. Protein concentration was determined by a protein assay kit (Bio-Rad, CA, USA) according to the Bradford method. Sample solution (100 μL) was mixed with 5.0 mL of diluted dye reagent and was incubated at room temperature for at least 5 min. Sample was measured at 595 nm using a Beckman model DU 650 photometer (Beckman Instruments Tnc., CA, USA). Protein concentration of each loaded supernatant onto the gel was approximately 13%.

2.7. Thermal properties of rice noodles

Differential scanning calorimetry (DSC 200 f3 maia, NETZSCH, Bavaria, Germany) was used to investigate the effect of TGase and RPI on the thermal properties of rice noodles. Ground rice noodles (5.0 mg) were weighed into stainless still pans, distilled water (15.0 mg) was added, and the pans were hermetically sealed. After 12 h at room temperature, the samples were heated from 10 to 140 °C at a rate of 10 °C/min. The DSC instrument was calibrated with indium, stannum, and bismuth, and empty sealed pan was used as a reference.

2.8. Morphological properties of rice noodles

The surface structure of the rice noodles was analysed by Field Emission Scanning Electron Microscopy (FE-SEM). Rice noodles were frozen at −80 °C for 24 h, and dried using a freeze-dryer