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Effect of konjac glucomannan on physical and sensory properties of noodles made from low-protein wheat flour

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ABSTRACT

In this study, the effects of konjac glucomannan (KGM) on Chinese noodles made from low-protein wheat flour were studied. Noodles were prepared from wheat flour/KGM blends by replacing low-protein flour at 1%, 2%, 3%, 4% and 5% with konjac glucomannan (KGM). The cooking and textural properties, microstructure and sensory characteristics were evaluated. KGM addition contributed to higher cooking yield and lower cooking loss for the resultant noodles. The sensory quality of KGM noodles was better than that of the control, although the control scored highest in stickiness. Sharp changes were observed around 5% substitution level in TPA parameters. Scanning electron microscopy (SEM) confirmed changes in noodle microstructure as KGM addition affect cooked starch granule structure and gluten network development. In general, noodles with 3% KGM were relatively desirable in textural properties and scored best in sensory evaluation, indicating the potential for improving textural defect of noodles prepared from low-protein wheat flour by using KGM.

1. Introduction

Noodles are one of the major traditional cereal products in Asia favored by consumers for their ease of handling and cooking. Noodle quality is assessed as a combination of appearance, texture, eating quality, and cooking properties (Zhu, Cai, & Corke, 2010), among which texture is generally considered as the most important quality parameter. Noodles are sensorically preferred when they are firm, elastic and low in cooking loss and stickiness (Tan, Li, & Tan, 2009). In turn, noodle quality is influenced by flour composition, in particularly, starch and protein levels (Baik, Czuchajowska, & Pomeranz, 1994; Chaisawang & Suphantharika, 2005; Herranz, Borderias, Solo-de-Zaldívar, Solas, & Tovar, 2012; Wang, Kovacs, Fowler, & Holley, 2004), cooking yield (Ma, Wang, Xu, & Lu, 2009), moisture content (Wang et al., 2004), and presence of non-starch polysaccharides (Inglett, 2005; Kishk, Elsheshetawy, & Mahmoud, 2011). Both protein quantity and quality are critical to noodle quality, with the consensus among many researchers that protein content of wheat flour has a positive correlation with textural properties including hardness, cohesiveness, gumminess and chewiness (Baik, Czuchajowska, & Pomeranz, 1994; Hu, Wei, Wang, & Kovacs, 2007). Therefore, the suitability of wheat flour for noodle production can be gauged by the protein content of flour, which has been traditionally regarded as an indicator for the prediction of noodle quality. It was reported that wheat flour with protein content greater than 11% was required for acceptable noodle processing and texture (Park, Hong, & Baik, 2003).

Konjac glucomannan (KGM) is extracted from the root tuber of the *Amorphophallus* konjac plant (Khanna & Tester, 2006) and has been used as a generally recognized as safe (GRAS) food ingredient. Konjac glucomannan (KGM) is composed of β-1,4-linked D-mannosyl and D-glucosyl residues at a molar ratio of 1.6:1.0 as the main chain with a small number of branches through β-1,3-mannosyl units (Katsuraya et al., 2003; Maeda, Shimahara, & Sugiyama, 1980). KGM is regarded as a noncalorie providing food ingredient, due to one of its primary benefits as an indigestible dietary fiber, which has been demonstrated to be effective in weight reduction, modification of intestinal microbial metabolism, and cholesterol reduction (Chua, Baldwin, Hocking, & Chan, 2010). Additional to the health-promoting benefits of KGM, it is widely used in food, beverage and pharmaceutical industries for thickening, texturing, gelling and water imbibing (Chua et al., 2010; Takigami, 2000). KGM can promote synergistic effects when combined with both protein and starch, and thereby forming different textures. In the presence of KGM, mechanical strength in compression of collagen hydrogel scaffold was enhanced (Weska, Achilli, Beppu, & Mantovani, 2011), where thermodynamic incompatibility occurred between denatured whey protein and KGM (Tobin, Fitzsimons, Chaurin, Kelly, & Fenelon, 2012). KGM is effective filler for improving both strength and adhesiveness of myofibrillar protein gels (Xiong et al., 2009). With respect to KGM/starch interactions, a preliminary study showed that KGM might promote thermodynamic incompatibility (Yoshimura, Foster, Norton, & Nishinari, 1999). KGM was applied to control rheology and structure of potato starch (Khanna & Tester, 2006; Silva, Birkenhake, Scholten,

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Sagis, & van der Linden, 2013), cassava starch (Shanavas, Moorthy, Sajeev, Misra, & Sundazeem, 2010), and maize starch (Yoshimura, Takaya, & Nishinari, 1998), revealing that the behavior of KGM is similar to a physical barrier to prevent amylopectin chain association (Khanna & Tester, 2006). However, KGM could not improve the adhesiveness, chewiness and hardness significantly for any kinds of rice starches (Huang, Kennedy, Li, Xu, & Xie, 2007).

There is, however, no literature dealing with how structural changes induced by KGM interacting with both wheat protein and starch contribute to macroscopic properties embodied in noodle quality. Therefore a fundamental study of KGM/starch/gluten can provide insight into an applied use of KGM in low-protein wheat noodles. Based on well-documented functions of hydrocolloids in modifying the strength and extensibility of structures in the presence of denatured protein or gelatinized starches (Rosell & Foegeding, 2007), using KGM to reinforce gluten network on low-protein noodle structure is expected.

The aim of this study is to evaluate the effects of KGM addition on cooking, sensory, and textural properties of Chinese noodles made from low-protein wheat flour. The microstructures of noodles in the presence of KGM before and after cooking were also studied.

2. Materials and methods

2.1. Materials

Commercial wheat flour ('Great value' brand) was purchased from De Jiafu Flour Mills (Guangdong, China). Konjac glucomannan was supplied by Yuanli Biotechnology Co., Ltd. (Hubei, China). The contents of ash, crude protein, fat, and glucomannan were 0.8 g/100 g, 2.2 g/100 g, <0.5 g/100 g and 95.6 g/100 g (dry basis, w/w), respectively. Analyses (moisture, ash, dry gluten, wet gluten) of wheat flour incorporated with different KGM substitution levels were performed according to approved methods of AACC (2000) (methods 44-15, 08-01 and 38-12, respectively) in triplicate and the results were expressed as average.

2.2. Noodle preparation

Using 30% water absorption of commercial low-protein flour (0% KGM) for desirable noodle dough as a reference, optimum amount of water for different formulated flours is pre-determined through farinographic test. Water absorption values from farinograph assays were 32%, 34%, 37%, 41% and 44% for the dough with 1%, 2%, 3%, 4% and 5% KGM, respectively.

Noodles were prepared using the method previously described by Li, Huang, Yang, and Wang (2012) with some modifications. The formulated flours with different proportions of KGM substitution (0%, 1%, 2%, 3%, 4% and 5%) were mixed thoroughly before kneading. Water was mixed with 200 g formulated flours in a small scale kneader (Kenwood, UK) with planetary kneading action over a 30 s interval at the mini speed setting for 10 min. The dough was allowed to rest for further 10 min and then sheeted on a noodle machine (Kenwood, UK) with an initial gap setting of 3.0 mm followed by progressively narrowing gaps to 1.2 mm to ensure homogeneity. From this sheet, the noodle strands of 3 mm in width and 20 cm in length were produced by cutting blades (Kenwood, UK) and placed in plastic bags for further tests.

2.3. Cooking properties

In this study, all the noodles were cooked for a fixed time of 3 min. Water adsorption and cooking loss were determined as previously described by Lu, Guo, and Zhang (2009) with small modifications. Ten strands were weighted and added to a beaker containing 400 mL of boiling tap water. Noodles were cooked for 3 min with slight agitation. The cooked noodles were rinsed in cold water for 30 s and drained for 5 min before weighting. The cooking yield of the cooked noodles was calculated as a percentage increase in weight of the uncooked noodles. Cooking water of 100 mL was evaporated and dried in an oven at 105 °C to constant weight. Cooking loss was calculated as the percentage of the residue on the weight of noodles before cooking. Results presented are adjusted to dough of 30% water absorption due to that the water absorption is quite different in the range from 30% to 44%.

2.4. Texture profile analysis (TPA)

After cooking, the strands were placed in 250 mL distilled water (20 °C) to cool down for 3 min and drained for 5 min, immediately followed by texture profile analysis using the TA-XT2i texture analyzer (Stable Micro Systems, UK). Each single cooked noodle strand tested had a cross sectional area of approximately 5 mm and a length of 5 cm. A set of three strands was placed parallel with space between each strand at 0.5 cm on a flat metal plate. Samples were compressed twice to 25% of original sample height using an R/36R probe at a pre-test, test, and post-test speed of 0.8 mm/s. The trigger type is 'auto' with trigger force of 5.0 g. Three replicate samples were tested. Four TPA parameters were obtained from the force–time curve: hardness, adhesiveness, springiness and cohesiveness.

2.5. Microstructure of the cooked KGM noodles

The raw and cooked noodles were cut transversally into cubes, immediately frozen at −80 °C and lyophilized. Freeze-dried samples were mounted on a silver specimen holder and coated with gold for 60 s. Microstructure of cross-section was observed by a Scanning Electron Microscope (HITACHI, Japan) at a voltage of 15.0 kV with micrographs taken at magnification of 600×.

2.6. Sensory evaluation

Six noodle samples with different KGM concentration ratios (0%, 1%, 2%, 3%, 4% and 5%) were prepared for sensory evaluation in terms of firmness, elasticity, stickiness and overall acceptability. Forty trained panelists comprising twenty females and males from the College of Food Science & Nutritional Engineering of China Agricultural University were tested to evaluate the presented samples using bipolar scale, say −3 for dislike extremely, −2 for dislike very much, −1 for dislike slightly, 0 for neither like or dislike, 1 for like slightly, 2 for like very much, and 3 for like extremely. Measurement of preference was achieved by determining which sample scored higher than another. A balanced-block design for six-product test was used. Each sample appeared equally in each serving position across the panel within each session. Each panelist received twelve strands of noodle per sample. To avoid sensory fatigue, the sensory test was divided into four separate sessions. Panelist was requested to assess only one attribute in a session.

2.7. Statistical analysis

Except for the sensory evaluation which was repeated in duplicate, all the other experiments were performed in triplicate. The results were statistically analyzed using SPSS (SPSS Inc., Chicago, USA). Analysis of variance (ANOVA) was used to determine significant difference between the results and Duncan's test was used to separate the mean with a significance level of 0.05.

3. Results and discussion

3.1. Characterization of the wheat flours incorporated with different KGM substitution levels

Before determining the effect of KGM on noodle properties, the composition of each formulated flour was assessed (Table 1). Introduction of different amounts of KGM into wheat flour diluted the total