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Study on processing and quality improvement of frozen noodles

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ABSTRACT

The processing method and quality improvement of frozen noodles were studied. To obtain the best mouthfeel and control the breakage during processing and cooking, noodles with a thickness of 1.1 mm and width of 3.4 mm were produced. The precooking method for raw noodles was steaming for 10 min and then boiling for 4 min before freezing to obtain the optimal characteristics for frozen noodles. Five frequently used food additives (guar gum, sodium stearyl lactate (SSL), cassava starch, glucose oxidase (GOD), and α-amylase) were used to improve the quality of frozen noodles. Cooking losses and sensory evaluation scores were adopted to optimize the formulation of frozen dough by a response surface methodology (RSM): guar gum 0.28%, SSL 0.44%, cassava starch 4.82%, GOD 0.003%, and α-amylase 0.04%. Frozen noodles had a more continuous microstructure and their storage quality was improved notably by this method.

1. Introduction

Noodles are being eaten since thousands of years. They are popular for their ease of cooking and nutritional qualities. Noodles account for 30–45% of wheat consumption in most S.E. Asian countries. It has been estimated that at least 12% of the global wheat production is used for making Asian noodle products (Gan, Ong, Wong, & Easa, 2009). Fresh noodles are very popular in most parts of China, where the preferred flavor, firmness, elastic texture, and chewiness of noodles differ depending on the region (Cai, 1998; Hou, 2001). However, the shelf-life of fresh noodles is very short because of the high contents of water and nutrients (Xu, Clifford, Wolf-Hall, & Manthey, 2008), which will deteriorate quickly if not stored under refrigeration. Another disadvantage of fresh noodle is that they darken, while most consumers prefer noodles that are bright and clean in appearance. The short shelf-life of fresh noodles has resulted in high levels of wastage in the industry, and it might also be a potential source of food poisoning (Ghaffar, Abdulamir, Bakar, Karim, & Saari, 2009).

After the first instant noodles were produced by Nissin Foods of Japan in 1958, instant noodles immediately became a mainstream food, and their consumption started not only in Asia but also worldwide. Most instant noodles are fried in oil after steaming and molding (Kim, 1996). Steamed and deep-fried noodles have an average oil content of 15–22%. Health concerns about the fat in fried noodles have led to the production of steamed and hot-air dried instant noodles, although they lack the distinctive flavor introduced by deep-frying. Moreover, their overall eating quality is not as good as the steamed-and-fried noodles. Long-life (LL) noodles have been popular over the years. The general process for producing LL noodles includes boiling, cooling, acidifying, packaging, low-temperature thermal processing, and cooling. LL noodles are healthy and usually have a shelf-life of three months (Fu, 2008). However, LL noodles are not delicious because of the acid, alcohol, or other treatments used for their preservation.

Consumption of frozen food, which can be prepared easily and in different ways and which stays closest to fresh food despite being off-season, is increasing. Among the factors contributing to the increased demand for frozen food are the entry of women into the work force and the resulting lifestyle changes. Nowadays, more and more people prefer to eat outside or eat fast. The frozen food industry has grown very rapidly in recent years. The expansion of frozen rice and flour products has been included in the 2011–2015 five-year plan formally adopted by the China's legislature (National Development and Reform Commission and Ministry of Industry and Information Technology of China, 2011). By applying chilling and quick-freeze technologies, the fresh quality of boiled noodles can be extended for a reasonable period of time. Most of the frozen noodles are sold to restaurants equipped with specially designed boiling pots. It takes less than 1 min to thaw a piece of frozen

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noodle, which can then be easily mixed with a sauce or soup and be ready to serve. Frozen boiled noodles allow restaurants to serve tasty noodles conveniently and efficiently without the need to provide employees with special training in noodle preparation. Although frozen noodles are becoming more popular, they account for only 4–5% of the total noodle production, even in Japan (Fu, 2008). The frozen noodle industry was initially developed during the last decade in China. There are several companies in China that produce frozen noodles, although the market for frozen noodles is not growing very fast. One reason is that the production of frozen noodles is aimed at people with high incomes. At the same time, most of the frozen noodles available in the market cannot meet people's expectations for instant noodles that taste as good as fresh noodles.

Although broad outlines for the production of frozen noodles are listed in various industrial patent applications (Hirose, 1986; Meye, Scoville, & Jaelminger, 2001; Ozawa, Hayakawa, Kato, Kobayshi, & Fuse, 1992), there is little in the scientific literature about frozen noodle processing. Betchaku and Niihara (1999) pointed out that rapid freezing tended to have less effect on the rheological properties of the noodles than did slow freezing; Hatcher (2004) investigated different frozen-noodle-processing conditions and their subsequent effects on the cooked noodle texture and reached the conclusion that blanching, rather than optimally cooking prior to freezing, can yield frozen noodles with desirable texture characteristics. Many additives such as natural gum (Charlesa et al., 2007), enzymes (Wu & Corke, 2005), whey protein isolate (WPI), casein, chitosan, and pregelatinized starch (Chillo, Suriano, Lamacchia, & Del Nobile, 2009) have been used to improve the flavor and texture of fresh noodle products. However, as far as we know, the application of additives to frozen noodles has been limited to dry-heated egg white and modified wheat starch (Ono, Seib, & Takahashi, 1999; Tachi, Ogawa, Shimoyamada, Watanabe, & Katoh, 2004). Therefore, research to improve the quality of frozen noodle products is necessary.

The present study discusses noodle-processing parameters, precooking methods, and quality improvement by additives.

2. Materials and methods

2.1. Materials

High-protein wheat flour special grade No. 1 (Zhengzhou Haijia Food Co., Ltd., Zhengzhou, China) was obtained from the local market and stored at 25 °C during the study. The moisture, protein, ash, and wet gluten contents of the wheat flour were determined according to approved methods of the American Association of Cereal Chemists (AACC): Methods 44-15A, 46-13, 08-01, and 38-12A (AACC, 2000). Farinograph, extensograph characteristics, and the falling number of the wheat flour were determined by AACC approved methods 54-20, 54-10, and 56–81B, respectively (AACC, 2000). Salt and sodium bicarbonate were procured from the local market. Guar gum, sodium stearyl lactate (SSL), cassava starch, glucose oxidase (GOD), and α-amylase were generously provided by the Honest Additive Company (Zhengzhou, China).

2.2. Noodle preparation

Noodles were prepared using the method described by Hou (2010). The noodle formula consisted of 200 g of flour and 60 g of distilled water. During the processing, 1% salt, 0.1% sodium bicarbonate, and other additives were dissolved in water and then hydrated. The dough was formed using an S5A multifunction mixer (Guangzhou Wellmax Industrial Co., Ltd., Guangzhou, China) and mixed for 15 min. The prepared flocculated mixture was placed to rest in a plastic bag for 15 min. Then, the mixture was sheeted on a customized mini laboratory combination noodle machine (Custom made, Beijing Tengwei Machinery Co., Ltd., Beijing, China) with an initial gap setting of 3.0 mm. Two passes were made at this setting with the noodle sheet folded between the passes to ensure homogeneity. The dough sheet was subjected to three further reduction passes before being cut. Different noodle cutters were used to obtain noodle strands with different widths and thicknesses. The noodles were cut into 200-mm-long strands for further research. Imperfect noodle strands were picked out and eliminated. Noodles were divided into several subsamples for the cooking method study.

Fresh control noodles were prepared, optimally precooked in boiling water until no visible core was present (8 min), rinsed under running distilled water maintained at 20 °C, drained, and stored in sealed containers at room temperature (22 °C) for 10 min before being analyzed. For comparative purposes, a subsample of the freshly prepared raw noodles was optimally cooked (by boiling or steaming), rinsed, drained, divided into several pieces (350 g per piece), and shaped in a round container (with a thickness of about 2 cm) before being transferred to the −40 °C freezer. After 2 h at −40 °C, frozen noodle cakes were transferred to a −18 °C freezer for prolonged storage. The frozen noodles were taken from the freezer after the specified storage intervals, immediately immersed in boiling water without thawing and cooked for 1 min to duplicate normal consumer behavior. Cooked noodles were rinsed and drained as described above prior to testing.

2.3. Cooked noodle instrumental texture analyses

Textural properties of cooked noodles were measured using a TA-XT Plus texture analyzer (Stable Micro Systems, London, England) under optimal test conditions. Measurements were carried out at room temperature exactly 10 min after cooking (AACC, 2000; Oh, Seib, Deyoe, & Ward, 1983). The calibration settings were 5 kg for the load cell with a return trigger path of 15 mm. Every sample was composed of five strands of noodle laying on the test board in parallel form, upright to the probe cutter. Texture measurements of the cooked noodles were replicated six times for each sample. Then, the average was calculated after discarding the maximum and minimum values.

Chewiness was determined from the texture profile analysis (TPA) using a P35 probe operating in the compression mode. The compression mode settings (pretest, test, and posttest speeds) were 1.0, 0.8, and 0.8 mm/s, respectively; the strain was set at 70%; the trigger type was set to auto-5 g.

Firmness was determined by an A/LKB-F probe in the compression mode with the following mode settings: pretest, test, and posttest speeds were 1.0, 0.8, and 10.0 mm/s; the force was 1000 g; the trigger type was auto-5 g; the broken sensitivity was 10.0 g (Approved Method 66-50 (AACC, 2000)).

Extensibility was determined using an A/KIE probe in the tension mode with a test speed of 3.30 mm/s and a distance of 50.0 mm according to the description of Wu and Corke (2005).

2.4. Cooking-loss determination

The cooking loss, defined as the amount of solid substance lost into the cooking water, was determined as described by AACC Method 66-50 (AACC, 2000). A 10-g sample of noodles was placed into 500 mL of boiling distilled water for the optimal cooking time, and rinsed using 50 mL of distilled water. The cooking water and rinsing water were collected in a beaker and placed into an air oven at 105 °C until dry. The residue was weighed and reported as a percentage of the starting material.