LWT - Food Science and Technology 97 (2018) 396–403

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Comparative study of cooking quality, microstructure, and textural and sensory properties between fresh wheat noodles prepared using sodium chloride and salt substitutes

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ARTICLE INFO

Keywords:
Sodium chloride
Salt substitutes
Fresh white salted noodles
Microstructure
Sensory properties

ABSTRACT

The effects of sodium chloride (NaCl) and commercial salt substitutes (SS) on cooking qualities, microstructure, textural and sensory properties of fresh wheat noodles were studied. NaCl and four types of SS were added at 1, 4 and 8% of flour weight. White salted noodles (WSN) had shorter optimum cooking time than zero-salted noodles (ZSN). Cooking yield of ZSN, WSN-NaCl-1, WSN-NaCl-8, WSN-SS3-1 and WSN-SS3-4 were significantly ($P < 0.05$) higher than other noodles. Increment of salts resulted in significantly increased ($P < 0.05$) cooking loss but did not significantly affect ($P > 0.05$) springiness of noodles. Addition of salts into noodles, except WSN-NaCl-1, WSN-NaCl-8, and WSN-SS2-8 were firmer than ZSN. WSN-SS2 and WSN-SS4 exhibited densest microstructure than ZSN and WSN-NaCl. Ranking test indicated that replacing NaCl with SS2, SS3 and SS4 up to 8% in noodles could retain elasticity of noodles. SS2 and SS4 may be useful to replace NaCl due to better noodles qualities than ZSN and WSN-NaCl.

1. Introduction

Noodles are a staple food for consumers in most of Southeast Asia and China. Since the basic ingredients of wheat flour-based Asian noodles are wheat flour, water, and salt or alkaline salt, these noodles are often categorized into the following two types: white salted noodles (with added salt) or yellow alkaline noodles (with added alkaline salt) (Fu, 2008; Li et al., 2018).

The wheat flour components (*i.e.* starch and proteins), sodium chloride (NaCl), and alkaline salt impact quality of dough and noodles. NaCl is important in processing, taste, and preservations of food products (Hutton, 2002). NaCl (< 3%) tightens and strengthens gluten structure by promoting aggregation of gliadins and glutenins via intermolecular hydrogen bonds and/or ionic bonds and allowing more proteins to cross-link (Morris, Jeffers, & Engle, 2000; Rombouts, Jansens, Lagrain, Delcour, & Zhu, 2014; Ukai, Matsumura, & Urade, 2008). Thus, NaCl addition produces a more elastic and stable dough resulting in less sticky and easier handling of dough (Hutton, 2002; Li, 2016). NaCl also enhances the palatability of food by imparting a desirable salty taste when it dissociates into ions (https://www.ncbi.nlm.nih.gov/books/NBK50958/, Bartoshuk, 1980).

SS are gradually getting more attention due to changes in nutritional concept of consumers. SS perform the same functions as salt and being marketed to circumvent the risk of diseases associated with a high salt intake. Research in the field of SS in food products has intensified recently and has been extensively reviewed. dos Santos et al. (2015) reported that reduction of 50% of NaCl by potassium chloride has reduced firmness of dry fermented sausages whereas addition of calcium chloride reduced the degradation of sarcoplasmic proteins in processing and increased the hardness of the fermented sausages. Meanwhile, from Charlton, Macgregor, Vorster, Levitt, and Steyn (2007), replacement of 32% of sodium with a mixture of magnesium chloride, potassium chloride and magnesium sulphate in breads were comparable to taste and texture of regular bread.

To our knowledge, there is no literature dealing with the effects of SS on fresh wheat noodles. Thus, a fundamental study of various types of SS can provide insight into application of SS in fresh wheat noodles. The typical amount of NaCl added into WSNs may contain up to 8% on flour weight basis. NaCl is important in noodle production but high levels of NaCl are detrimental to health. Therefore selected SS with certain percentages were added to eliminate NaCl and maintain the qualities of ZSN and WSNs. SS can be introduced into noodles to replace NaCl during formulating and mixing. SS which will enhance protein network in noodles are preferred. The main objective of this study was to compare the effects of NaCl and SS on qualities of noodles.

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https://doi.org/10.1016/j.lwt.2018.07.031
Received 15 January 2018; Received in revised form 17 June 2018; Accepted 15 July 2018
Available online 17 July 2018

2. Materials and methods

2.1. Materials

Commercial wheat flour (14.0% moisture content, 10.5% protein content on dry matter basis) well-suited for production of fresh salted noodles was purchased from Seberang Flour Mill Sdn. Bhd. (Penang, Malaysia). NaCl was purchased from Tesco Stores (M) Sdn. Bhd. (Georgetown, Malaysia). SS1 was purchased from Morton Salt Company (Chicago, IL, USA), and SS2 was purchased from NuTek Food Science Company (Omaha, NE, USA). SS3 was purchased from Cumberland Packing Corp. (Brooklyn, NY, USA), and SS4 was purchased from Reckitt Benckiser Company (Parsippany, NJ, USA).

2.2. Noodle preparation

Control noodle dough consisted of 100 parts of wheat flour and 35 parts of distilled water. Next, on a flour weight basis, NaCl, SS1, SS2, SS3 and SS4 were added separately at 1, 4, or 8%. The levels of addition were selected based on the typical range of usage levels of NaCl in regular salted noodles which is 1–8% of the flour weight. Salts solutions were prepared by dissolving salts in water prior to addition with wheat flour. Designations of noodles samples are given in Table 1. Ingredients were mixed into crumbly dough using a mixer (Spar Quart Planetary, SP 8, Taichung, Taiwan) at mixing speed 2 for 6 min. After mixing, the crumbly dough was rolled and hand kneaded into a stiff mass. Dough was placed in a plastic zip lock bag to rest for 30 min at 23 °C. After resting, the dough was passed through a pasta maker (Marcato Ampia, Model 150, Campodarsego PD, Italy) with an initial gap setting at width 0 (2.2 mm) for 5 times. After the first sheeting stage, the dough sheet was placed in a polyethylene bag for 30 min at 23 °C (second resting stage). It was then successively sheeted through three different roll gaps which were width 1 (2.0 mm), width 2 (1.8 mm), width 3 (1.6 mm), and width 4 (1.4 mm). Immediately after the second sheeting stage, the sheet was cut into fresh noodle strands using the same pasta maker. The dimensions of the resultant noodle strands were 1.4 mm in width and 1.1 mm in thickness.

Table 1
Formulation of ZSNs, WSN-TS, WSN-SS1, WSN-SS2, WSN-SS3, and WSN-SS4.

Types of noodles	Ingredients (g)						
	Wheat flour	Distilled water	NaCl	SS1	SS2	SS3	SS4
ZSNs	100	35	–	–	–	–	–
WSN-NaCl-1	100	35	1	–	–	–	–
WSN-NaCl-4	100	35	4	–	–	–	–
WSN-NaCl-8	100	35	8	–	–	–	–
WSN-SS1-1	100	35	–	1	–	–	–
WSN-SS1-4	100	35	–	4	–	–	–
WSN-SS1-8	100	35	–	8	–	–	–
WSN-SS2-1	100	35	–	–	1	–	–
WSN-SS2-4	100	35	–	–	4	–	–
WSN-SS2-8	100	35	–	–	8	–	–
WSN-SS3-1	100	35	–	–	–	1	–
WSN-SS3-4	100	35	–	–	–	4	–
WSN-SS3-8	100	35	–	–	–	8	–
WSN-SS4-1	100	35	–	–	–	–	1
WSN-SS4-4	100	35	–	–	–	–	4
WSN-SS4-8	100	35	–	–	–	–	8

ZSN-Zero-salted noodles. WSN-NaCl-1, WSN-NaCl-4, and WSN-NaCl-8 represent white salted noodles containing NaCl with 1, 4, and 8% of flour weight basis, respectively. WSN-SS1-1, WSN-SS1-4, and WSN-SS1-8 represent white salted noodles containing SS1 with 1, 4, and 8% of flour weight basis, respectively. WSN-SS2-1, WSN-SS2-4, and WSN-SS2-8 represent white salted noodles containing SS2 with 1, 4, and 8% of flour weight basis, respectively. WSN-SS3-1, WSN-SS3-4, and WSN-SS3-8 represent white salted noodles containing SS3 with 1, 4, and 8% of flour weight basis, respectively.
WSN-SS4-1, WSN-SS4-4, and WSN-SS4-8 represent white salted noodles containing SS4 with 1, 4, and 8% of flour weight basis, respectively.
"-" denotes absence of the ingredient in the formulation.

2.3. Determination of cooking qualities

2.3.1. Optimum cooking time

Optimum cooking time of noodles was determined by withdrawing five noodle strands from the boiling water after 5 min and subsequently at 30 s intervals. The noodles were rinsed and gently squeezed between two Plexiglas sheets. Optimum cooking time was defined as the time at which the white core in the central core in a noodle strand disappeared (Hatcher, Dexter, Anderson, Bellido, & Fu, 2009). Cooked noodles were immediately cooled in distilled water at 20 °C for 3 min. Samples were withdrawn for further analysis.

2.3.2. Cooking yield

Cooking yield and cooking loss were determined as previously described by Zhou et al. (2013) and Tan, Phatthanawiboon, and Easa (2016) with slight modifications. For each measurement, 10 strands of uncooked noodle was weighed and then boiled in 400 mL of distilled water at optimum cooking time of each sample with slight agitation. The cooked noodle was rinsed in cold water for 30 s and drained for 5 min before weighing. The cooking yield of the cooked noodles was calculated as (noodle weight after cooking/weight of uncooked noodles) x 100 and it represents the ability of noodles to absorb water during cooking.

2.3.3. Cooking loss

Cooking loss was determined by evaporating 100 mL of the cooking water in a hot air oven at 105 °C to constant weight. Cooking loss was determined by measuring the weight of solid substance lost from noodle strands into the cooking water. There are 3 measurements were taken for each type of noodle, and the values were averaged.

2.4. Texture profile analysis (TPA)

Noodle samples were cooled in distilled water for 3 min right after cooking and drained for 5 min before being subjected to TPA (Zhou et al., 2013). Texture analyser (Stable Micro Systems, TA-XT Plus, London, England) fitted with a 5 kg load cell was used for this measurement. TPA was performed by placing 3 strands of cooked noodle samples (length 70 mm) in parallel on the middle of the compression plate using pasta firmness rig (HDP/PFS). The instrument settings were as followed: Mode, measure force in compression; Trigger type, auto with trigger force of 20 g; Pre-test speed, 2.0 mm/s; Test speed, 0.8 mm/s; Post-test speed, 0.8 mm/s; Strain, 75%; Interval between two compressions, 1.0 s (Li, Foo, Liong, Tan, & Easa, 2013; Lu, Guo, & Zhang, 2009). There were 2 continuous compressions and 3 measurements were taken for each type of noodle, and the values were averaged. The textural parameters which are hardness (N) and springiness were obtained from the force (N) - distance (mm) curve.

2.5. Microstructure analysis

A scanning electron microscope (SEM) (Leo Supra 50, Oberkochem, Germany) was used to observe the microstructures of cooked ZSN and 1% and 8% of WSN-NaCl, WSN-SS2 and WSN-SS4. Before SEM analysis, noodle samples were being fixated with glutaraldehyde and then freeze dried (Labconco Corporation, Freezone 12, Kansas City, MO, USA). Next, dried noodle samples were fractured and mounted on specimen stubs with the fractured side faced up. The mounted noodle samples were coated with Pt-Pd, and cross-section of the noodles was observed with the SEM at 300× magnification (Li et al., 2013).