Food Chemistry 194 (2016) 797–804

Contents lists available at ScienceDirect

Food Chemistry

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

Quality characteristics, structural changes, and storage stability of semi-dried noodles induced by moderate dehydration Understanding the quality changes in semi-dried noodles

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ARTICLE INFO

Article history:
Received 25 January 2015
Received in revised form 24 July 2015
Accepted 20 August 2015
Available online 21 August 2015

Keywords:
Semi-dried noodle
Dehydration temperature
Quality
Storage stability
Structure

ABSTRACT

Based on the critical water content (for noodle deterioration) concluded previously, high-temperature–short-time (HTST; 105–135 °C) and medium-temperature–long-time (MTLT; 45–75 °C) dehydrations were introduced in this study to produce semi-dried noodles. The effects of HTST and MTLT on the quality parameters of semi-dried noodles, as well as noodle structure, storage stability, and changes in starch and protein components were thoroughly investigated. Differential scanning calorimeter (DSC) and birefringent analysis presented few starch gelatinization (approximately 30%) in HTST dehydrated noodles. Scanning electron microscopy (SEM) images showed more compact noodle surface, with uniform pores in the cross section, probably due to enhanced protein–starch combination after HTST dehydration. Meanwhile, HTST induced protein polymerizations in semi-dried noodles, mainly by –SH–S–S interchange, and resulted in significantly ($P < 0.05$) reduced cooking loss. Furthermore, HTST noodles showed higher microbial and color stability. Shelf-life of dehydrated samples at 120 °C was extended to 5 days from 1 day of the control.

1. Introduction

Noodles, as a staple food in many Asian countries, have a history of over 4000 years. Noodle consumption has increased worldwide because of its convenience, nutritional quality, and palatability (Li et al., 2012).

Generally, people could only buy dried noodles or instant fried noodles in supermarkets for ease of preservation. However, the deep drying processes may decrease the flavor, texture, and even nutritional properties of noodle products. Therefore, fresh noodle, as the traditional form of Chinese noodles, is now attracting more people for its unique flavor and taste. Nevertheless, with a high water content (over 30%) and initial microbe quantity, fresh noodle is extremely prone to spoilage and must be stored under refrigeration (Li, Zhu, Guo, Peng, & Zhou, 2011). Ensuring the basic circulation of these products is even impossible. In addition, fresh noodles are vulnerable to darken due to the accelerated PPO (polyphenol oxidase)-mediated discoloration and other darkening reactions under high water content, which is considered as a major limiting factor of noodle marketability (Asenstorfer, Appelbee, & Mares, 2010).

Our previous study concluded that 23–24% was the critical water content of fresh noodle deterioration (unpublished). Darkening and microbial growth rate rapidly increased above this moisture level. Therefore, reducing the water content of the products to this relatively safe level is desirable. These products are called semi-dried noodles, which ensure both the similar flavor and taste to fresh noodles and a prolonged shelf-life (Zhu et al., 2013). All these advantages may make semi-dried noodles increasingly popular with consumers, thereby increasing their production and potential marketability.

Water is necessary for the development of gluten network in noodle production, thus reducing the water amount during dough mixing is inadvisable. Several studies have been conducted on moderate dehydration technologies to distinguish semi-dried noodles from fresh noodles, which satisfied reduced moisture content in the end products without compromising the desired eating quality (Liang, Chen, Wang, & Lv, 2012; Zhu et al., 2013). At present, studies on the dehydration technologies for semi-dried noodles mostly focus on the traditional low temperature technology. Liang et al. (2012) optimized the medium-dehydration temperature (25–45 °C) for semi-dried noodles processing. High-temperature dehydration equipments have been recently introduced in China and Japan for the moderate dehydration of semi-dried noodles

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http://dx.doi.org/10.1016/j.foodchem.2015.08.079
0308-8146/

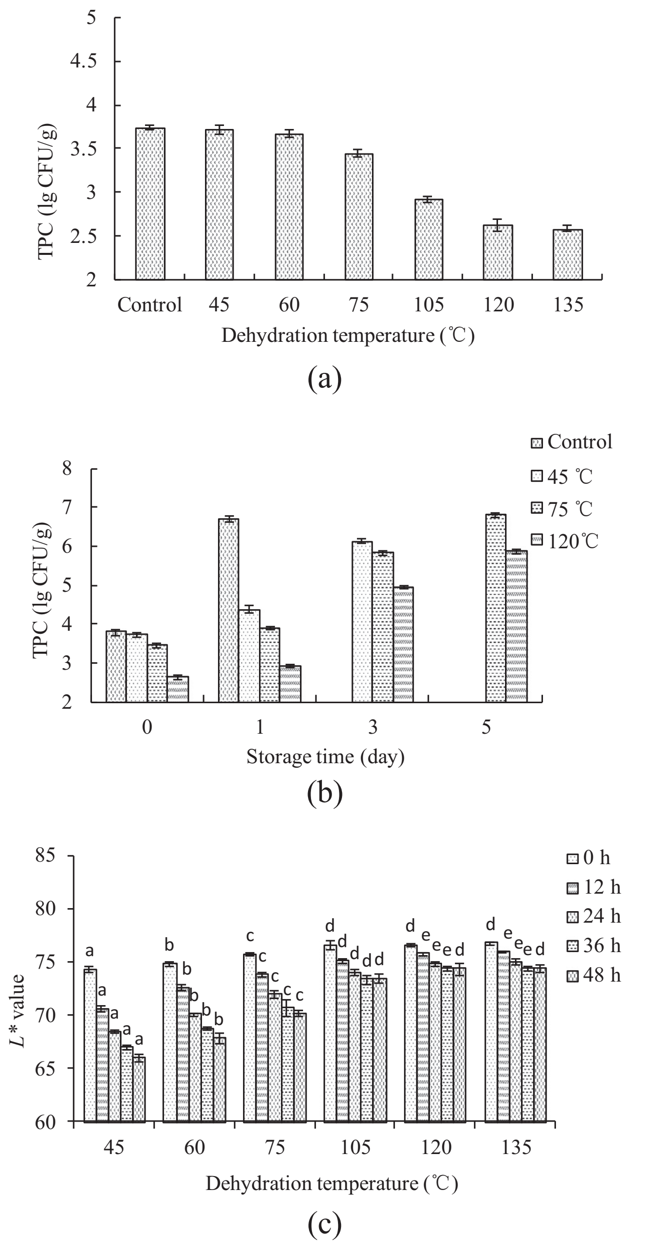

Fig. 1. TPC and L^* value changes in semi-dried noodles: (a) TPC changes after dehydration at different temperatures; (b) TPC changes during storage; and (c) L^* value changes of samples dehydrated at different temperatures.

(Zhu et al., 2013). The equipment possesses simultaneous capabilities of preliminary sterilization and decreasing the initial microbe content and oxidase activity. Shi and Wang (2005) also proposed the potential of high-temperature dehydration as a new drying technology for Chinese dried noodles.

However, to our knowledge, no research has been conducted on the effects of dehydration temperature (especially the comparison of high and low temperature) on the eating quality, structure, and major component (such as protein and starch) changes in semi-dried noodles. Therefore, this work aimed to apply high-temperature–short-time (HTST; 105–135 °C, 30–200 s) and medium-temperature–long-time (MTLT; 45–75 °C, 5–20 min) dehydration to fresh noodles; and to investigate the effect of HTST and MTLT drying on quality characteristics and storage stability semi-dried noodles.

2. Materials and methods

2.1. Materials and proximate analysis

High-protein wheat flour (using for ramen, fresh noodles and dumplings) was produced by China Oil and Foodstuffs Corp., Beijing, China. Moisture, ash, and protein content were 13.5%, 0.57% and 13.1%, respectively, as determined according to the AACC methods 44-15A, 46-12, and 08-01, respectively (AACC, 2000). All chemical reagents used were of analytical grade.

2.2. Preparation of semi-dried noodles

The noodle formula consisted of 2000 g of flour and 700 mL of distilled water. The dough was formed using a small vacuum mixer (Model ZHM5-S; Zhengzhou, Henan, China) under −0.06 MPa. The mixing speed and time were as follows: first at 71 rpm for 20 s (low-speed), then turned to 135 rpm for 180 s (high-speed), and at last 89 rpm for 360 s (medium-speed). The prepared dough was allowed to rest in a sterilized plastic bag for 30 min. The dough crumbles were then passed through an experimental noodle machine (Model JMTD-168/140; Beijing, China) for 6–8 times, with the roller gap reduced gradually from 1.5 mm (initial gap) to obtain dough sheets. The strands of resultant noodles were 1 mm in width and 0.8 mm in thickness. The noodle samples were cut into pieces of 20 cm in length and treated using a tunnel electric heating equipment (Model GZX-9246 MEB; Shanghai, China) for moderate dehydration. Temperatures were set as 45, 60, and 75 °C for MTLT dehydration, and 105, 120, and 135 °C for HTST dehydration. Two independent noodle samples were made for each dehydration temperature, and the water content of the end products was reduced to the same level (23.5 ± 0.5%) after different dehydration times (12, 8, 6 min; 200, 150, and 105 s, respectively from 45 to 135 °C). The dehydrated semi-dried noodles were enclosed in an aseptic chamber for 1 h to ensure a uniform water distribution. A portion of the noodle samples were then freeze dried for subsequent analyses.

2.3. Determination of TPC

Semi-dried noodle samples were analyzed for total plate count (TPC) and color after dehydration and periodically during the storage period. TPC was examined according to GB/T 4789-2008 (Code of National Standard of China, 2008). A 25 g sample was placed into 225 mL of 0.85% aseptic physiological saline, and the mixture was shaken in a stomacher bag using a stomacher machine (Lab-blender 400; Seward Laboratory) for 60 s. Serial dilutions were prepared using 0.85% aseptic physiological saline, and 1 mL of the appropriate dilutions was pour plated onto sterile plate count agar (PCA) plates. The plates were then incubated at 37 °C for 48 ± 2 h before enumeration.

2.4. Color measurement of semi-dried noodle sheets

The color of the MTLT and HTST dehydrated semi-dried noodle sheets was measured with a chroma meter (Konica Minolta CR-400; Japan) equipped with D65 illuminant, using the CIE L^*, a^*, and b^* color scale. L^* is a measurement of brightness (0–100), a^* represents the red-green coordinates (− is green and + is red) while b^* measures the blue-yellow coordinates (− is blue with + indicating yellowness) of a product.