LWT - Food Science and Technology 53 (2013) 61–69

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

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

The influence of emulsifiers on the rheological properties of wheat flour dough and quality of fried instant noodles

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ARTICLE INFO

Article history:
Received 1 October 2012
Received in revised form
21 January 2013
Accepted 30 January 2013

Keywords:
Rheological characteristics of wheat flour dough
Emulsifier
Instant noodle

ABSTRACT

In order to improve processing performance and functionality of wheat flour dough, the influence of emulsifiers including distilled mono-glycerides (DMGs), polysorbate-60 (P60), and diacetyl tartaric esters of mono-glycerides (DATEM) on dough rheological properties and quality of fried instant noodles have been investigated. Farinograph, extensograph, and scanning electron microscopy analysis were conducted to characterize the dough rheological property. The addition of P60 and DATEM in dough strengthened its rheological properties, being indicated by high stability, low degree of softening within 12 min, increase in resistance to extension, and enhancement of extensibility in comparison with the control. The quality of noodle including sensory, water content, degree of gelatinization, and oil content was evaluated. As compared to the control, the oil content in fried instant noodle with the addition of 0.2 g P60/100 g and 0.2 g DATEM/100 g flour reduced 18.3% and 9.9%, respectively; the time of rehydration decreased 25.0% and 12.5%, respectively; and the degree of gelatinization increased 10.2% and 8.1%, respectively. Both P60 and DATEM showed a significant impact on springiness, firmness, and overall acceptability in noodles. The results clearly indicate that dough rheological characteristics and quality of noodles improved with the addition of certain emulsifiers.

1. Introduction

Noodles gain popularity due to their ready-to-eat convenience, cost competitiveness, availability of various products with different taste and texture, beneficial nutrition, and long shelf-life. Globally, the consumption of wheat noodles is second only to bread (Ding & Zheng, 1991; Shin & Kim, 2003), with nearly 40% of wheat being processed into noodles in Asia (Crosbie, 1991; Hou, 2001). Recently, the consumption of instant noodle has been increasing in the fastest pace in cereal foods (Choy, Hughes, & Small, 2010; Yu & Ngadi, 2004). Therefore, understanding dough functionality and promoting quality are of high interest for a successful and controlled production of noodles.

Dough characteristics mainly include viscoelasticity, extensibility, springiness, cohesiveness, water and oil holding capacity. The elements relevant to dough structure are proteins, starch granules, and entrapped air. In the processing of dough development, water was mixed with wheat flour. During kneading, the hydrated proteins start to become interconnected, resulting in a continuous spatial network which is classically described as the continuous gluten phase (Jekle & Becker, 2011). The viscoelastic protein network consists of glutenin (elastic properties) and gliadin (viscous properties) as primary hydrophobic proteins (Koehler, Kieffer, & Wieser, 2010). The second continuous phase is composed of free water where starch granules and hydrophilic components are located (Breuillet, Yildiz, Cuq, & Kokini, 2002). The third phase consists of dispersed gas. The use of additives like emulsifiers, enzymes, antioxidants, and modified celluloses is a common practice to improve processing and mechanical performance of flours (Stauffer, 1998). Particularly, the addition of emulsifiers into dough brings in important consequences on processing procedure, since emulsifiers change the interaction of hydrophilic and hydrophobic phases, further leads to changes in rheological properties of dough. Consequently, the quality parameters including springiness, smoothness, chewing and mouth-feel in noodles can be correspondingly altered, which can also affect the sensorial attributes in finished product, resulting in an impact on consumers' acceptability.

The mechanisms of emulsifiers to improve dough processing properties have been ascribed to their ability to bind to glutens

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0023-6438/$ – see front matter
http://dx.doi.org/10.1016/j.lwt.2013.01.031

(Inoue, Tugita, Koike, Suzuki, & Kamoi, 1996), and to form complexes with starch (Krog, Olesen, Toernaes, & Joensson, 1989). Emulsifiers bind the protein hydrophobic surface to promote aggregation of glutens in dough. A strong protein network results in better texture and increased volume of bread (Kamel & Ponte, 1993). Hydrophilic emulsifiers may also form lamellar liquid-crystalline phases in water, which is associated with gliadin. These structures make contributions to dough elasticity allowing gas cell to expand, thus giving rise to an increased volume of baked food (Tamstorf, Jonsson, & Krog, 1986). Distilled mono-glycerides (DMGs) are commonly utilized as anti-staling agents and account for approximately one third of the emulsifiers used in the baking industry (Stauffer, 2000). Structurally, DMGs are made from hydrogenated fats with stearate (C18:0) being the most common fatty acid. They function as mild dough conditioners, leading to boosted dough processing properties and improved slicing performance (Stampfli & Nersten, 1995). Mono- and di-acylglycerols esterified to mono- and di-acetyltartaric acids are anionic oil-in-water emulsifiers which are commonly applied to improve bread volume, texture and dough stability (Mettler & Seibel, 1993). Upon added to dough, this kind of emulsifiers enhances mixing tolerance, gas retention, and resistance of the dough to collapse. In consideration of the finished products, emulsifiers may boost loaf volume and endow it with resilient texture, fine grain as well as slicing properties (Inoue, Sapirstein, & Bushuk, 1995; Tamstorf et al., 1986). Polysorbates are nonionic surfactants consisting of polyoxyethylated fatty acid esters of sorbitan with a total of 20 ethylene oxide equivalents per molecule. These surfactants are widely used to impart certain desirable qualities to the food product.

Emulsifiers are widely used to improve the quality of bread, however, little information was found on the effect of these emulsifiers on the quality of fried instant noodles. The objective of this study is to examine the effect of emulsifiers on dough formation, to analyze rheological behavior and microstructure of wheat flour dough, as well as the quality change in fried instant noodles.

2. Materials and methods

2.1. Materials

2.1.1. Flour

The white wheat flour was commercially available and provided by Henan Yikang Co. Ltd (Shuiping, Henan, China). This flour has 11.4 g protein/100 g flours and 14.2 g/100 g moisture content.

2.1.2. Emulsifier

Both distilled monoglyceride (DMGs) and polysorbate-60 (P60) were purchased from Meichen Group (Guangzhou, China). Diacetyl tartaric acid esters of mono-glycerides (DATEM) were from Danisco Co., Ltd. (Panodan M2020, DANISCO®, Copenhagen, Denmark).

2.2. Methods

2.2.1. Farinographic assay

A farinograph measures rheological properties of flours by determining the resistance of the dough against the mixing action of paddles. Briefly, flour and emulsifier were blended with 1.5 g/100 g salt. Dry ingredients were pre-mixed and the farinographic assay was conducted according to the standard method (AACC, 2000) in a 300 g Brabender Farinograph equipment (Brabender GmbH & Co KG, Germany). Each emulsifier was added to the flour at five levels of 0, 0.10, 0.20, 0.30, and 0.40 g/100 g flour basis. The parameters obtained from farinogram were percentage of water to yield consistency of 500 BU (water absorption), time to reach up to 500 BU (development time), time that dough remains at a consistency of 500 BU (dough stability time), and degree of softening 12 min from the consistency of 500 BU.

2.2.2. Extensographic assay

An extensograph measures the stretching properties of the dough, in particular the resistance to extension and the extensibility of a dough by determining the force required to stretch the dough with a hook until it breaks. In this study, an extensograph-E (Brabender GmbH & Co KG, Germany) was used to study the effects of emulsifiers on the energy value (area under the curve, cm^2), resistance to extension (*R*, Bu), dough extensibility (*E*, mm), and *R*/*E* value in 45 min according to the standard method (AACC, 2000). Emulsifiers levels used were 0, 0.10, 0.20, 0.30, 0.40 g/100 g flour.

2.2.3. Scanning electron microscopy (SEM) analysis of dough

SEM images of dough prepared with 0.20 g/100 g emulsifier were performed. The control sample was free of the emulsifiers. Briefly, dough samples were fixed in 30 mL/L glutaraldehyde for 24 h, washed 3 times with 0.1 mol/L phosphate buffer, submerged in series acetone solutions for 5 min and then in 100% acetone for 30 min to obtain complete dehydration. Samples were dried at the critical point and coated with gold. A SEM (Hitachi 430, Japan) was used to observe the samples. The magnification was set at 2000.

2.2.4. Preparation of instant noodles

Dough development: The dough formulation contained 300 g flour (13 g/100 g moisture basis), 60 g sodium chloride, 0.8 g sodium propionate, 0.06 g ascorbic acid, different level emulsifiers, and 132 g of water (optimal level based on farinograph assay). Ingredients were thoroughly blended in an Argental L-20 mixer (Santa Fe, Argentina) for 3 min. Sodium chloride, sodium propionate and ascorbic acid were dissolved in water, added into the ingredients, and then stirred for 15 min. Water was chilled to achieve dough temperature 30 °C after mixing.

Press sheeting and cutting: the crumbly dough was sheeted through the first roll gap four times, and folded in half each time using an Electric Pasta Making Machine (Mercato, Italy). The dough sheet covered with a piece of 8 μm odorless PE plastic film was rested for 15 min. The dough piece was reduced to a final thickness of 0.9 mm through nine pairs of successive rollers without intermediate resting stages, and then cut into 25 cm length, 2 mm wide strips with a roller cutter.

Steaming and oil frying: The fresh noodles were steamed at 95–98 °C in a steamer for 180 s and fried in palm oil at 148 °C using a domestic type electric fryer (Meidi Roto Fryer, Guangzhou, China) for 120 s.

Cooling and packaging: Fried noodles were drained for 20 min in an air cabinet and cooled to 20 °C. Finally the instant noodles were stored in plastic bags and sealed for analysis.

2.2.5. Sensory evaluation of instant noodle

The sensory evaluations were performed using a descriptive profile test based on a Chinese National Standard (GB/T 25005, 2010). Briefly, nine panelists were trained using the Spectrum method (Meilgaard, Civille, & Carr, 1991) for approximately 60 h to master the texture lexicon which contained 17 terms covering the categories of surface, first chew, and chew down. The total mark of sensory evaluation for one sample was 100 points including 5 points for color, 25 points for smoothness, 20 points for firmness, 40 points for springiness, 10 points for overall acceptability. The intensity of attributes was scored by a scale of 1 (extremely low) to highest score of index point (extremely high). The vocabulary of the descriptions and the intensity level of references for all attributes were generated through consensus. Sensory evaluation was made after storage of 5 days at 22 ± 2 °C and 75 ± 5% relative humidity (RH).