LWT - Food Science and Technology 53 (2013) 88–93

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

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

Utilization of preharvest-dropped apple powder as an oil barrier for instant fried noodles

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ARTICLE INFO

Article history:
Received 25 September 2012
Received in revised form
11 February 2013
Accepted 20 February 2013

Keywords:
Preharvest fruit drop
Apple
Instant fried noodles
Oil uptake
Frying

ABSTRACT

The effects of preharvest-dropped apple powder (PDAP) on the functional properties of instant fried noodles were investigated in terms of rheological, textural, and oil-resisting properties. When wheat flour was replaced with PDAP at 10, 20, and 30% by weight, the oil absorption index of wheat flour was reduced by 6 ~ 9% while there was an increase in the temperature of starch gelatinization which could be attributed to its high content of dietary fiber and sugar. In a wheat dough system, the water absorption decreased with increasing levels of PDAP (55.9–37.0%) while the dough stability was enhanced (7.4–11.9 min). The rheological and textural measurements showed that the use of PDAP for wheat flour produced noodle dough samples with less viscoelastic and tensile properties, which could be correlated to the reduced breaking stress of fried noodles. Furthermore, the incorporation of PDAP into the noodle formulation produced a more compact and continuous structure of the noodle samples with fewer and smaller voids. Thereby, PDAP had a significant impact on the oil uptake of fried noodles which was reduced by 42% at a PDAP level of 30%.

1. Introduction

Preharvest fruit drop takes place as fruits progress through the ripening period (Robinson, 2011). Although the vulnerability to preharvest fruit drop is dependent on many factors such as fruit variety, local climate, and disease severity, it is commonly caused by endogenous ethylene (Dal et al., 2008). Therefore, the main research focus has been mostly placed on the development and application of substances that can control the synthesis and release of ethylene. In addition, the exposure to an unexpected weather condition can cause heavy preharvest fruit loss, consequently giving rise to severe economic damage to the agricultural industry. For instance, a typhoon (Bolaven) that occurred in Korea (August 2012) was expected to reduce the annual production of apples and pears by 5% and 27%, respectively, compared to their initial production estimation (MFAFF, 2012). However, most of the preharvest-dropped fruits appeared to exhibit less acceptable external appearance, consequently losing their commercial market value. Therefore, a great deal of effort needs to be exerted for delivering higher values to the preharvest-dropped fruits. Specifically, the utilization of preharvest-dropped fruits as a functional food ingredient, can be of great economic benefit to the food industry as well as fruit growers.

Instant noodles, also known as instant ramen, have been globally enjoyed because of various factors such as their short cooking time, diverse tastes, and low product cost. Hence, the global market of instant noodles was projected to reach nearly 100 billion packets in 2011 (WINA, 2012). In order to derive this demand for instant noodles, the noodle industry needs to make a great deal of effort for improving the functional quality attributes of existing products and also introducing new products into the market that satisfy the potential needs of current health-conscious consumers. As one of the efforts, various cereal sources other than wheat such as rice and buckwheat have been applied to instant noodles for reducing the risk of gluten-derived celiac diseases (Fu, 2008). In the case of instant fried noodles, they are prepared from steaming followed by deep-fat frying. Therefore, a high level of oil and calorie is a primary concern of the instant fried noodles. For example, instant cup noodles are reported to contain the highest amount of oil ranging from 20 to 37% (Hou, 2010). Several studies reported the methods to reduce the oil uptake of instant fried noodles by using acetylated potato starch/sodium carboxymethyl cellulose (Choy, May, & Small, 2012), guar gum (Yu & Ngadi, 2004), and transglutaminase (Choy, Hughes, & Small, 2010). However, there are still limited trials to produce instant fried noodles with a reduced content of oil and

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0023-6438/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.lwt.2013.02.022

calorie. In addition, fruit-derived ingredients have not been evaluated as an oil barrier for fried noodles to our best knowledge.

In this study, preharvest-dropped apple powder (PDAP) was prepared and incorporated into the formulation of instant fried noodles. Then, the effect of PDAP on the quality attributes of the noodles was investigated in terms of rheological, textural, and oil-resisting characteristics.

2. Materials and methods

2.1. Materials

Fuji apples that were preharvest-dropped in 2011 by a weather disaster, were obtained from a Chungju orchard (Chungcheongbuk-do, Korea). The apple cores were removed with a knife and the apples were sliced with a Cuisinart food processor (Connecticut, USA). After freeze-drying, the apple samples were ground to pass through a 30 mesh screen and stored in a plastic bag. In the case of wheat flour, all-purpose wheat flour was obtained from CJ Co. Ltd. (Seoul, Korea). All chemical agents used in this study were of analytical grade.

2.2. Physicochemical characterization of preharvest-dropped apple powder

2.2.1. Determination of dietary fiber and sugar

The AOAC-approved method (AOAC, 2005) was used to determine the content of total, insoluble, and soluble dietary fiber in PDAP. Also, the sugar profile of PDAP (glucose, fructose, and sucrose) was analyzed according to the method of Rastegar, Rahemi, Baghizadeh, and Gholami (2012). PDAP (3 g) was mixed with distilled water (25 mL) at room temperature for 10 min and then centrifuged at 8000 *g* for 10 min. The supernatant was then filtered through a 0.45 μm filter (Toyo Roshi Kaisha Tokyo, Japan) and diluted with distilled water ($\times 10^3$), which was injected into the HPAEC-PAD system (BioLC®, Dionex Corporation, CA, USA) equipped with a CalboPac™PA1 column (4 × 250 mm, Dionex Corporation, CA, USA). 18 mM NaOH was used as an eluant and the flow rate was 1 mL/min.

2.2.2. Measurement of oil absorption index

The effect of PDAP on the oil absorption of wheat flour was investigated. Wheat flour was replaced with PDAP at 0, 10, 20, and 30% by weight, and each sample (0.5 g) was mixed with grape seed, soybean, and canola oils (6 mL) in pre-weighed centrifuge tubes. The samples were agitated for 1 min on a vortex mixer to disperse the sample in the oil and placed at room temperature for 30 min. After centrifugation at 3000 *g* for 25 min, the separated oil was removed and the tubes were inverted for 25 min to completely drain the oil. The oil absorption index was calculated as the weight ratio of wet sediment to dry sample.

2.2.3. Thermal analysis

A differential scanning calorimeter (DSC 200 F3 Maia, NETZSCH, Bavaria, Germany) was used to investigate the effect of PDAP on the thermal properties of wheat flour. Wheat flour-PDAP mixtures were prepared by replacing wheat flour with PDAP (0, 10, 20, and 30% by weight), and distilled water (20 mL) was added to each mixture (5 mg) in an aluminum pan. After hermetically sealed, the pans were left at room temperature for 1 h and then heated from 20 to 90 °C at a rate of 5 °C/min. Distilled water was used as the reference material. The peak temperature (°C) and enthalpy (J/g) of starch gelatinization were measured.

2.2.4. Mixolab thermo-mechanical characterization

The changes in the thermo-mechanical properties of wheat flour by PDAP were investigated by using a Mixolab (Chopin, Tripetteet Renaud, Paris, France). Wheat flour was replaced with PDAP at 0, 10, 20, and 30% by weight and the blend was loaded into a Mixolab bowl. Distilled water was automatically added to reach optimum consistency (1.1 Nm). During mixing, the dough sample was subjected to the programmed heating and cooling cycle (holding at 30 °C for 8 min, heating to 90 °C for 15 min (4 °C/min), holding at 90 °C for 7 min, cooling to 50 °C over 5 min (4 °C/min), and finally holding at 50 °C for 5 min). From the Mixolab curves, torque values (Nm), water absorption (%), dough stability time (min), and development time (min) were determined.

2.3. Application of PDAP into instant fried noodles

2.3.1. Preparation of instant fried noodles

Noodle samples were formulated with all-purpose wheat flour (100%), NaCl (1.5%), and distilled water (40%). For PDAP noodles, wheat flour was replaced with PDAP at 10, 20, and 30% by weight. Dry ingredients were mixed with distilled water where NaCl was dissolved for 1 min and hand-kneaded for 5 min. The dough was sheeted with a sheeting roller of which gap was sequentially reduced to 1.4 mm, and then passed through a cutting roller to produce noodle strands (12 cm long and 4 mm wide). The noodles were subjected to steaming for 5 min and frying in fresh soybean oil (1.6 L) at 170 °C for 1.5 min, followed by cooling at room temperature for 1 h.

2.3.2. Dynamic viscoelastic measurement

A controlled-stress rheometer (AR1500ex, TA Instruments, New Castle, DE, USA) with a serrated parallel plate (40-mm diameter) was used to investigate the dynamic viscoelastic properties of noodle dough. A frequency sweep test was carried out in a frequency range from 0.1 to 10 Hz at 25 °C, and the strain used in this study was 0.05% which was within the linear viscoelastic limit. Water evaporation from samples was prevented by covering the samples with mineral oil after loading on the rheometer fixture.

2.3.3. Textural measurements

The textural properties of noodle strands were measured by using a texture analyzer (TMS-Pro, Food Technology Co., Virginia, USA). Noodle strands before steaming were stretched at 100 mm/min by a Kieffer dough and gluten extensibility rig. The maximum resistance force to extension (R_{max}, N) and extensibility (E, mm) were measured. Also, in the case of fried noodles, a three-point bending test was performed where the stress required to break the noodles was calculated, according to the method of Heo et al. (2013).

2.3.4. Measurement of oil content

The effect of PDAP on the oil uptake of instant fried noodles was investigated. Oil from the noodle samples was extracted with diethyl ether in a Soxhlet apparatus according to the AOAC method (AOAC, 2005).

2.3.5. SEM microstructure

The surface microstructure of instant fried noodles was evaluated by using a scanning electron microscope (SEM) (S-4300, Hitachi, Tokyo, Japan). In order to obtain clear SEM images, the fried noodles were freeze-dried and defatted by ethyl ether for 24 h. They were then mounted on the top of an aluminum stud and coated with platinum in an ion sputter coater (E-1030, Hitachi, Tokyo, Japan).

2.4. Statistical analysis

Five measurements of the textural properties of noodle strands were made and other experiments were carried out in triplicate. The results were statically analyzed with SAS software (SAS Institute, Cary, NC, USA). Analysis of variance was applied at a