Food Chemistry 135 (2012) 2163–2169

Contents lists available at SciVerse ScienceDirect

Food Chemistry

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

Evaluation the quality characteristics of wheat flour and shelf-life of fresh noodles as affected by ozone treatment

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ARTICLE INFO

Article history:
Received 12 May 2012
Received in revised form 14 June 2012
Accepted 26 June 2012
Available online 14 July 2012

Keywords:
Ozone treatment
Wheat flour
Microorganism mortality
Physicochemical property
Shelf-life
Fresh noodle

ABSTRACT

In this study, the effects of ozone treatment on the microorganism mortality in wheat flour and shelf-life of fresh noodles were investigated, as well as the physicochemical properties of wheat flour and textural qualities of cooked noodles. Results showed that the total plate count (TPC) can be largely reduced in wheat flour exposed to ozone gas for 30 min and 60 min. Whiteness of flour and noodle sheet, dough stability, and peak viscosity of wheat starch were all increased by ozone treatment. Free cysteine content in wheat flour was shown to decrease significantly ($P < 0.05$) as the treatment time increased and remarkable protein aggregates were observed in both reduced and non-reduced SDS–PAGE patterns. In addition, ozone treated noodles were generally higher in firmness, springiness, and chewiness, while lower in adhesiveness. Microbial growth and darkening rate of fresh noodles made from ozone treated flour were delayed significantly.

1. Introduction

Noodle, a traditional staple food in many Asian countries, has been consumed for thousands of years. It is becoming increasingly popular worldwide for its convenience, nutritional quality, and palatability (Li et al., 2012). For quite a long time, people could only buy dry noodles or instant fried noodles in supermarkets for ease of preservation. However, the drying process may largely decrease the flavour, texture, and nutritional properties of noodle products. For that, as the traditional form of Chinese noodles, fresh noodle is now attracting more and more people for its unique flavour and taste (Cai, 1998).

However, the shelf-life of fresh noodles is very short due to high water content and nutrient substances. They will deteriorate quickly during storage, which therefore limits their manufacture and spread (Li, Zhu, Guo, Peng, & Zhou, 2011a; Xu, Hall, Wolf-Hall, & Manthey, 2008). One of the most important factors leading to the perishability of fresh noodles is the high level of microorganisms in wheat flour, which is the main raw material for noodle making. Usually, the total plate count (TPC) in newly produced noodles is nearly 10^4 CFU/g, and it is then up to 10^6 CFU/g (the level of incipient spoilage (Ghaffar, Abdulamir, Bakar, Karim, & Saari, 2009) even at the second day. At present, the most common way to maintain the freshness of these products turns to use various chemical preservatives, such as potassium sorbate, sodium dehydroacetate and calcium propionate. However, it must be highlighted that nowadays consumers are increasingly concerning about the safety of current food additives and becoming interested in natural "green" food (Serrano, Martínez-Romero, Castillo, Guillén, & Valero, 2005). For that, the antimicrobial action of several natural ingredients, such as flaxseed (Xu et al., 2008) and Maillard reaction products (MRPs) prepared from chitosan and xylose (Huang, Huang, Huang, & Chen, 2007), has been attempted in fresh noodle system. The major concern related to natural preservatives is that they may not provide a sufficient level of safety with regards to the control of bacteria load, in addition to the high cost. For all these reasons, it is important to investigate the effect of other techniques on the shelf-life extending of fresh noodles.

Ozone is highly reactive and is well known as a strong oxidising agent, it can cause elevation of reactive oxygen species in living cells, leading to oxidative stress in the cells and therefore is one of the most potent disinfectant agents. In 1997, ozone was recognised by U.S. Food and Drug Administration (FDA) as a GRAS (i.e. Generally Recognized as Safe) substance for use as a disinfectant or sanitizer in food industry (Alexandre, Brandão, & Silva, 2011). One advantage of ozone is that it finally breaks down into atmospheric oxygen, eliminating the potential residue of hazardous chemicals (McDonough, Mason, & Woloshuk, 2011). It can therefore be safely used in both gaseous and aqueous forms as an antimicrobial agent in the treatment, storage, and processing of foods, especially for fresh produce. In addition, due to its strong oxidising properties, ozone has been reported to act as an alternative to potassium bromate, chlorine, and benzoyl peroxide for treatment

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http://dx.doi.org/10.1016/j.foodchem.2012.06.103

of wheat flour (Sandhu, Manthey, & Simsek, 2011). However, to our knowledge, few published work has detailedly examined the effect of ozone treatment on the microorganism mortality and physicochemical properties of wheat flour; also no information is available on the shelf-life of fresh noodles as affected by ozone exposure.

The objectives of this work, therefore, were to study the effect of ozone exposure on the bacteria survival in wheat flour and the shelf-life of fresh noodles. In addition, the colour change, swelling power, thermomechanical and viscosity behaviours of wheat flour, as well as the textural properties and darkening rate of fresh noodles as affected by ozone treatment were also discussed.

2. Materials and methods

2.1. Materials

High protein white wheat flour was manufactured by China Oil & Foodstuffs Corporation (using for ramen, fresh noodles and dumplings), the contents of moisture, ash, and protein in which were 13.5%, 0.57%, and 13.1%, respectively. Table salt was purchased from the local market. All drugs and reagents used were of analytical grade.

2.2. Ozone treatment

The ozone gas treatment was conducted using an ozone generator (Mode OJ-8003k-A, Guangzhou, China) with a production of 5 g/h. Wheat flour was placed in an automatic revolving evaporation bottle to ensure a homogeneous contact between flour and O_3 during the reaction and treated for 1 min, 10 min, 30 min and 60 min, respectively. The airflow rate was set at 5 L/min. Two silicone hoses were connected to the bottle with one for importing the ozone gas and the other for exhausting the waste gas to the outside. For precaution purpose, disposable gloves and nose masks were used while working with ozone.

2.3. Polyphenol oxidase (PPO) activity assay

Extraction of PPO from wheat flour was similar to previously published procedures (Fuerst, Xu, & Beecher, 2008). 2 g of wheat flour was incubated in 10 ml of extraction buffer (0.1 M phosphate-citric acid buffer, pH 6.0) in a 15 ml centrifuge tube and shaken at 4 °C for 12 h. Polyphenol oxidase activity was determined by measuring the absorbance at 420 (A 420) nm using a spectrophotometer (Unocal UV-2800, U.S.A.). The PPO activity was calculated as difference in the absorbance of sample and control and expressed as Δ 420/min g flour.

2.4. Free Cys-S content determination

Free amino groups and Cys-S content were quantified in order to confirm the formation of covalent bonds caused by ozone treatment. Samples were analysed with an ODS HYPERSIL column on an automated amino acid analyzer by using High Speed Amino Acid Analyzer (HP 1100, Agilent, America). Wheat flour (about 1 g) was accurately weighted and precipitated by 10% solution of trichloroacetic acid. Then the mixture was filtered and the liquor was used for detection.

2.5. Viscosity analysis

Pasting properties of wheat flour exposed to ozone gas for 0 min, 30 min, and 60 min were determined with a Rapid Visco Analyser (RVA, Model Super-3, Newport Scientific, Warriewood, Australia), according to AACC method 76-21 (AACC International, 2000). Suspensions were made using pure deionised water (25 g) and the mixed flour (3.48 g) and manually homogenised using the plastic paddle right before the RVA test, then the tests were conducted in a programmed heating and cooling cycle.

2.6. Thermomechanical measurements

Thermomechanical properties, that is, the empirical rheological behaviours of flour dough, were evaluated with Mixolab (Chopin Technologies, Paris, France) using the ICC standard method No. 173 and Chopin + protocol (ICC, 2006). Wheat flour samples with known moisture content were placed into the Mixolab analyzer bowl at the amount calculated by the corresponding Mixolab analysis software on a 14%-moisture basis. After that, the water required for optimum consistency was added automatically by the Mixolab system to produce a dough torque of 1.1 ± 0.07 Nm. The settings used in the test were 8 min at 30 °C with a temperature increase of 4 °C/min until the dough reached 90 °C; and then, there was an 8 min holding period at 90 °C, followed by a temperature decrease of 4 °C/min until the dough reached 55 °C, and then 6 min of holding at 55 °C. The mixing speed during the entire assay was 73 rpm.

The parameters recorded in this study were water absorption (%), or the percentage of water required for the dough to produce a torque of 1.1 ± 0.07 Nm; dough development time (min), or the time to reach the maximum torque at 30 °C; dough stability (min), or time until the loss of consistency is lower than 11% of the maximum consistency reached during the mixing; mechanical weakening (Nm), or the torque difference between the maximum torque at 30 °C and the torque at the end of the holding time at 30 °C; peak torque (Nm), the maximum torque produced during the heating stage; cooking stability (Nm), which is calculated as the ratio of the torque after the holding time at 90 °C and the maximum torque during the heating period; and setback (Nm), which is defined as the difference between the torque produced after cooling at 50 °C and the torque after the heating period. The calculations were repeated three times for each blend.

2.7. Wheat flour and noodle sheet colour measurements

The colour of wheat flour and noodle samples with or without ozone treatment were measured using a Chromameter (CR-400, Konica Minolta Holdings Inc., Japan) portable spectrophotometer using the CIE L, a, b system.

2.8. SDS–PAGE (sodium dodecyl sulphate–polyacrylamide gel electrophoresis) analysis

SDS–PAGE was performed using 10% separating gel (pH 8.8) and 5% stacking gel (pH 6.8). Each sample (50 mg) was stirred in 1 ml of extraction buffer (0.01 M Tris–HCl, pH 6.8, including 10% (w/v) SDS, 5% (v/v) 2-mercaptoethanol (2-ME), 10% (v/v) glycerol, 0.1% (w/v) bromphenol blue). For non-reduced proteins, extraction buffer did not contain 2-ME. Samples were heated for 5 min at 100 °C, and then centrifuged for 5 min at 8000 g. Sample volumes of 7 μl were loaded into each well and electrophoresis was performed at 100 V during the run. The gel was stained with 0.25% w/v. Coomassie brilliant blue, and de-stained in 10% acetic acid.

2.9. Preparation of fresh noodles

The noodle formula consisted of 100 g of flour and 34 ml of distilled water. During the processing, 2 g NaCl was firstly dissolved in water. Ingredients were then hydrated and the dough was formed