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Quick-boiling noodle production by using infrared drying

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ABSTRACT

In this study, infrared treatment at different powers was used at drying stage of noodle production. Drying time was reduced to 3 min 30 s and 50% reduction in cooking time was obtained at the highest power. Lower cooking loss and total organic matter values, higher maximum force values were obtained for noodles dried by using infrared, indicating improved quality. Infrared treatment generally caused an increase in Rapid ViscoAnalyzer viscosity values of the noodles. Starch granules of the noodles dried by using infrared retained their birefringence to a large extent and increase in intensity of some peaks and formation of a new peak at $2\theta = 20°$ (V-type diffraction pattern) were observed in X-ray diffraction patterns. Relative intensities of some protein bands in SDS–PAGE patterns decreased, total dietary fiber and enzyme resistant starch contents increased slightly. Starch digestibility (*in vitro*) values increased gradually as the infrared power applied increased.

1. Introduction

Wheat flour noodles are staple foods in many Asian Countries. Noodle type product popular in Anatolia is called “eriste” and plays an important role in Turkish diet. Processing includes various stages such as mixing of wheat flour with water and salt, sheeting, cutting into strips and drying. In some regions, egg, milk, whey powder and some other additives are also included in the formula. Traditionally, “eriste” is generally dried under the sun, in an oven or in a roasting pan (Ozkaya et al., 2001). Various combinations of these drying methods might also be used. Most of the important quality factors are related to characteristics of raw material and drying stage, which is the most critical step in noodle production in terms of final product quality and economical aspects. Generally as noodle drying technologies, air drying, deep frying or vacuum drying are used. Air drying process is used in many noodle types (e.g. Chinese raw noodles, Japanese udon noodles, instant noodles). Drying time of 5–8 h is needed for air drying of long and straight regular noodles while it takes 30–40 min for steamed and air dried instant noodles. Drying by frying takes only a few minutes. Vacuum drying of frozen noodles gives premium quality products (Hou and Kruk, 1998). Characteristics preferred in dried noodles are minimal disintegration during cooking and smooth surface without stickiness (Oh et al., 1985). Ideally, drying processes could be designed to shorten drying time and to minimize energy and capital costs while maintaining high product quality. Several researchers investigated effects of various drying techniques or different drying temperatures on quality characteristics of pasta. Berteli and Marsaioli (2005) evaluated efficiency of air drying with assistance of microwave energy in short cut pasta production. A drying time reduction, a higher quality pasta, an increased production and reduced cost was obtained as compared to the one obtained in traditional process. Baiano et al. (2006) studied effects of different drying temperatures (60 °C for 7.5 h, 75 °C for 5.5 h, 90 °C for 5 h) on spaghetti quality and better cooking and sensory properties were obtained at the highest temperature. Pilli et al. (2009) reported that microwave caused reduction in cooking time and total organic matter (TOM) values of pasta samples as compared to conventional drying. In a study by Guler et al. (2002), it was found that pasta sample dried at high temperatures (60–67 °C) had lower quality scores based on TOM, cooking loss values and sensory evaluation as compared to the ones dried at very high temperature (80–94 °C).

Recently, with changes in our lifestyles, reduction of cooking time is expected because it takes a relatively long time for water outside the noodle to migrate into dried and ungelatinized center of noodle. Quick-boiling noodles are increasingly popular due to ease of preparation. Quick-boiling noodles on the market are pre-cooked and sometimes dried, fully pre-gelatinised in center or surface part of noodle (Thammathongchat et al., 2005). However, controlling degree of gelatinization during heating and drying stages are complex and difficult. Xue et al. (2008) produced a partially gelatinized noodle strain by making pre-heated dough using a 150 W microwave oven. For the partially gelatinized noodle, rate of water uptake at 100 °C was faster as compared to ungelatinized noodle. In a study by Thammathongchat et al. (2005), new type of processed Japanese noodle that is pre-gelatinized only in center was produced to overcome textural problems occurred during noodle production by surface gelatinization. Because of the precooked

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core, re-boiling time is reduced. At the same time it has good texture and firmness due to ungelatinized surface.

Technology innovations can also be applied to enhance noodle quality and adapt to consumer demands. In a preliminary study, we observed that infrared (IR) treatment used at drying stage of noodle is a useful tool to reduce cooking time in noodle. Infrared heating is an efficient food processing technology and has gained a great interest in food industry due to its advantages over conventional heating. Certain characteristics like thermal efficiency, fast heating rate/response time, wavelength, direct heat penetration into the product and reflectivity make IR heating more effective for some applications and provides considerable reduction in energy consumption (Skjöldebrand, 2001; Datta and Almeida, 2005; Sakai and Mao, 2006). Infrared heating has applications in drying, baking, roasting, blanching, pasteurization and sterilization of food products. It has been applied to reduce moisture content of various agricultural products including grains, legumes, fruit and vegetables (Hebbar et al., 2004; Nowak and Lewicki, 2004; Wang and Sheng, 2006; Nimmol et al., 2007). Infrared reduces cooking time by providing more open microstructure that enhances rehydration characteristics of lentils, increases starch gelatinization degree and reduces levels of antinutritional factors in some legumes (Arntfield et al., 1997; Scanlon et al., 1998; Zheng et al., 1998; Wiriyaumpaiwong et al., 2004; Bellido et al., 2006; Krishnamurthy et al., 2008). Infrared treatment affects physical, chemical, morphological, rheological and physicochemical properties of cereals and legumes. Infrared treatment was also used in production of bread (Skjöldebrand, 2002), cookies (Heist and Cremer, 1990) and tortillas (Martínez-Bustos et al., 1999). To the best of our knowledge, infrared was not used in noodle production and its effect on quality characteristics of noodles has not yet been studied.

In this study, infrared treatment at five different powers was used at the drying stage of noodle production. Drying of noodle in an infrared equipment can be rather troublesome because of rapid heating. Therefore, undesirable structural changes in noodle encountered during infrared drying were eliminated by using docking before drying and effects of infrared drying on quality characteristics of noodles were investigated.

2. Materials and methods

2.1. Materials

Grains of bread wheat cultivar (cv. Ikizce-96), obtained from Field Crops Central Research Institute (Ankara, Turkey), were tempered to a water content of 15.5% and milled into flour by a Buhler laboratory mill (Germany). Moisture, protein, ash contents, sedimentation value and farinograph properties of the wheat flour were determined according to Approved Methods of American Association of Cereal Chemists (AACC International, 2000).

2.2. Noodle production

Wheat flour was mixed with water (75% of farinograph absorption) in a mixer (KitchenAid K45SS, St. Joseph, MF) for 10 min. The dough was passed through reduction rolls of a noodle machine (Ampia 150, Italy) to produce a uniform dough sheet. The dough sheet was allowed to rest at 27 °C for 30 min in a plastic container. After resting, the dough sheet was again passed through the reduction rolls to obtain a dough sheet with a thickness of 2 mm. Long dough strips obtained from cutting rolls of noodle machine were docked in order to overcome undesirable structural changes occurred due to fast heating rate in infrared system. To prepare control noodle, docked strips were dried in an oven at 45 °C for 22 h. The other noodle samples were dried in infrared equipment (Biasis Ltd. Sti., Turkey) for 17 min, 9 min, 6 min, 4 min 30 s and 3 min 30 s at IR powers of 909, 1127, 1309, 1545, 1673 W, respectively. Drying times were determined in order to obtain final moisture content less than 8.5%. Three repetitions of dough were carried out for each trial in order to prevent differences arising from production and combined batch representing the noodle dried at that IR power was used for the analyses. Dimensions of the noodle samples were 4 cm × 6 mm × 2 mm (length, width, thickness) (Fig. 1).

Laboratory scale infrared equipment (Fig. 2) used in the study contains a drying chamber fitted with twelve 175 W halogen bulbs (Osram Siccatherm Bulb, Germany) which were set 20 cm above tray. The equipment also contains two aeration channels (12 V each) and a dimmer was used in order to arrange infrared power between 273 and 1782 W. Temperatures obtained within chamber for different IR powers were around 53 °C for 909 W, 70 °C for 1127 W, 88 °C for 1309 W, 108 °C for 1545 W, 128 °C for 1673 W. After drying, noodles were cooled to room temperature and then stored in plastic bags at room temperature for 2 weeks before analysis.

2.3. Cooking properties and texture analysis of noodle samples

Cooking time was determined as the time required for disappearance of the white core in the noodle strand after pressing between two glass plates. Cooking loss is the amount of solid substance lost to cooking water after optimum cooking time. The cooking water was collected in a tarred beaker and dried in an air oven at 98 °C for 24 h. The residue was weighed and reported as percentage of starting material. Water absorption (%) and swelling volume (%) of the noodles were calculated as follows;

$$\text{Water absorption}\,(\%) = \frac{\text{weight of cooked noodle} - \text{weight of uncooked noodle}}{\text{weight of uncooked noodle}} \times 100$$

$$\text{Swelling volume}\,(\%) = \frac{\text{volume of cooked noodle} - \text{volume of uncooked noodle}}{\text{volume of uncooked noodle}} \times 100$$

Total organic matter (TOM) is the surface material released from cooked product during exhaustive rinsing. It was determined according to method of D'Egidio et al. (1982) suggested for pasta products.

Texture of the noodles was determined by measuring maximum force on a Texture Analyzer (Lloyd Instruments Ltd., UK) after cooking the noodles for optimum time. For testing maximum force value, cooked noodle strand was wound two times around parallel rollers of a spaghetti-noodle testing fixture (FG/SPAG) to anchor ends of the strand and hinder slippage. The maximum force (N) is defined as the force required rupturing of the cooked noodle strand.

2.4. Pasting properties

Pasting properties of noodles were determined using a Rapid ViscoAnalyzer (RVA-4, Newport Scientific, NSW, Australia). A 3.5 g (14% moisture basis) ground noodle sample (<212 μm) was added to 25.0 g of distilled water (adjusted to correct for sample moisture content) in an aluminum canister. The pasting profile was obtained in the RVA with a 13 min test that involved an initial equilibration at 50 °C for 1 min, heating to 95 °C for 3 min 42 s, holding at 95 °C for 2 min 30 s, cooling to 50 °C for 3 min 48 s, and holding at 50 °C for 2 min. Peak, trough, breakdown, setback and final viscosity values were evaluated with the data analysis software (Thermocline, Newport Scientific, NSW, Australia). Correlation coefficients between RVA viscosity values and cooking