LWT - Food Science and Technology 84 (2017) 489–496

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

The role of hydration on the cooking quality of bran-enriched pasta

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ARTICLE INFO

Article history:
Received 7 December 2016
Received in revised form
5 June 2017
Accepted 7 June 2017
Available online 9 June 2017

Keywords:
Pasta
Wheat bran
Hydration procedure
Cooking and sensory quality
Gluten network
Disulphide bonds

ABSTRACT

Hydration of multi component systems, such as pasta enriched with wheat bran, is a complex phenomenon due to water competition in the mixture. The influence of the hydration method on the quality of wheat pasta loaded with wheat bran is addressed in this work. In particular, spaghetti containing wheat bran were produced by two different hydration methods: the durum wheat semolina and bran were first mixed together and then hydrated (-BT); durum wheat semolina and bran were separately hydrated and then mixed together (-BS). Two different concentrations of wheat bran, 20 g/100 g and 25 g/100 g, were prepared. Size exclusion-HPLC analysis was performed to investigate conformational polymeric changes of how the gluten network is affected by the hydration procedure. Sensory properties and the cooking quality of the samples were also assessed. Results suggest that the hydration method markedly affects the formation of disulphide bonds, suggesting that separate hydration increases the number of disulphide bonds, the strength of the gluten network. As a matter of fact, samples obtained by separated hydration recorded a significant improvement of both sensory attributes and cooking quality parameters as compared to samples obtained by simultaneous hydration.

1. Introduction

Recently, a growing demand for healthy food, such as products with high fiber content and low energy, has been observed (Anderson et al., 2009; Krishnan & Prabhasankar, 2012). Traditionally, pasta is manufactured from durum wheat semolina, known to be a good source of low glycemic index carbohydrates (Liljeberg & Björck, 2000; Björck, Liljeberg, & Ostman, 2000). The FDA considers pasta as a good vehicle for nutrients enrichment to increase its nutritional value and lower the energy value by incorporating dietary fiber sources into pasta formulation (Bustos, Perez, León, 2011; Chillo, Laverse, Falcone, & Del Nobile, 2008; Fuad & Prabhasankar, 2010; Rakhesh, Fellows, & Sissons, 2015). From a histological structure point of view, a complex biological material with a different chemical composition constitutes the durum wheat bran. It mainly consists of non-starch carbohydrates, which is not homogenously distributed and contains high levels of starch, protein, lipids, lignin and various minor components (Hemdane et al., 2016). Wheat bran can change the rheological and extrusion properties of the dough by causing discontinuity and a lack of homogeneity in the dough, compromising the formation of a cohesive network of gluten polymeric proteins that ultimately reduces the dough strength and mixing stability (Manthey & Schorno, 2002). As a matter of fact, dough development and quality are affected by wheat bran content due to the dilution of the gluten proteins, hindering proper gluten development by physically blocking the proper contact between the flour particles (Kaur, Sharma, Nagi, & Dar, 2012; Sobota, Rzedzicki, Zarzycki, & Kuzawinska, 2015). It was also found that the non-starch carbohydrates might cause a detrimental effect, interfering with proper gluten agglomeration. It has been suggested that the arabinoxylans interfere with gluten proteins, mainly by covalent binding of ferulic acid with tyrosine residues in gluten proteins, in turn affecting the formation of the gluten network (Piber & Koehler, 2005). This was substantiated by the observation that the addition of ferulic acid could prevent oxidative cross-linking during gluten formation (Wang, Oudgenoeg, van Vliet, & Hamer, 2003). Taking into account these findings, it appears clear that the strength of the gluten network can change in relation to the elements of discontinuity.

The durum wheat semolina hydration level is another key factor to be considered to obtain a strong gluten network (Jacobs, Hemdane, Dornez, Delcour, & Courtin, 2015; Yalla & Manthey, 2006). A level of hydration, different from the optimal one, brings about the formation of a weaker gluten network and, consequently,

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http://dx.doi.org/10.1016/j.lwt.2017.06.013
0023-6438/

a decrease in the sensory quality of pasta. When durum wheat semolina is the only constituent, it is easy to control its optimal hydration level. However, when semolina is mixed with other constituents, such as durum wheat bran, its hydration level is no longer under control due to the competition for the water molecules. In these cases, the adopted hydration methods can modify the hydration levels of the constituents, which in turn can affect the strength of gluten network formed via the extrusion process and, consequently, the sensory quality of pasta (Bock et al., 2015).

The aim of the present study was to determine the impact of a different hydration process on the gluten network formation in durum wheat spaghetti fortified with 20 g/100 g and 25 g/100 g of durum wheat bran. Size exclusion-HPLC analysis was used to determine the change of polymeric protein distribution as the pasta and the raw matter are affected by the hydration process. In addition, the effects of different hydration methods on sensory characteristic and cooking quality of pasta were also assessed.

2. Materials and methods

2.1. Raw material

Durum wheat seeds (*cultivar* PR22D89) were provided from the C.R.A. (Agricultural Research Council, Foggia, Italy). The durum wheat was milled in an experimental mill (roller mill Mod MLU202 Buhler). The bran was ground to fine flour on a Tecator Cyclotec 1093 (International PBI, Hoganas, Sweden) laboratory mill (1 mm screen, 60 mesh). The durum wheat semolina was characterized by a protein content of 13 g/100 g in dry matter, and by quality parameters: W 189 and P/L 2.1.

2.2. Spaghetti preparation

Spaghetti was produced with durum wheat semolina by using the following operating conditions: semolina was mixed with water using a rotary shaft mixer (Namad, Rome, Italy) at 25 °C for 20 min to obtain dough with 30 g/100 g moisture content. The bran was added at two concentrations: 20 g/100 g and 25 g/100 g, specifically, the bran was hydrated separately (20-BS and 25-BS) or together with durum wheat semolina (20-BT and 25-BT). The amount of water added has been modified according to the fiber-semolina dough to account for the higher water absorption capacity of the fibres (Table 1). In addition, for both the 20-BS and 25-BS formulations, the bran and semolina were mixed separately with water at 25 °C for 10 min. Once hydrated, semolina and bran were mixed together at 25 °C for 10 min. Spaghetti without any enrichment (100 g/100 g semolina pasta) were also manufactured and used as the reference sample (semolina pasta). The doughs obtained were extruded with a 60VR extruder (Namad) and dried in a dryer (SG600; Namad), as described by Padalino et al. (2013).

2.3. Size exclusion-high performance liquid chromatography (SE-HPLC) analysis

Proteins from semolina, bran and milled spaghetti (1 g) were extracted following the two-step extraction procedure (Gupta, Khan, & MacRitchie, 1993). The first step extracts the SDS-extractable proteins (proteins soluble in sodium dodecyl sulphate (SDS), whilst the second extraction contains the SDS-unextractable proteins (proteins soluble only after sonication). The protein extraction and HPLC analysis were performed in triplicate.

SE-HPLC was performed according to Johansson, Prieto-Linde, & Jönsson, (2001), using a liquid chromatograph Agilent 1100 Series system (Santa Clara, CA, USA) equipped with a Phenomenex Biosep SEC-S4000 column (300 × 7.8 mm, Phenomenex, Torrence, CA, USA). The SE-HPLC column was calibrated using protein standards with a range of molecular weights (kDa) as follows: Vitamin B_{12} (1.35), Myoglobin (17.0), ovalbumin (44.0), γ-globulin (158.0) and thyroglobulin (670).

The percentage of unextractable polymeric proteins (UPP) was calculated as described by Kuktaite, Larsson, and Johansson (2004).

Table 1
Spaghetti preparation.

	Semolina (g)	Water (ml)	Bran (g)	Water (ml)	Total Water (ml)
CTRL	2500	750	–	–	750
20-BT	2000	–	500	–	850
25-BT	1875	–	625	–	900
20-BS	2000	450	500	600	1050
25-BS	1875	400	625	750	1150

2.4. Determination of protein content

Nitrogen content of flours, pasta mixtures and of the residues obtained after the extraction of the unextractable polymeric proteins was estimated by the Kjeldahl method and was converted into protein by using a factor of 5.70. The analyses were carried out by an automatic digestion unit and through an automatic distillation and titration system (VELP Scientifica Srl, Usmate, Monza-Brianza – Italy). Three measurements for each sample were performed.

2.5. Determination of free thiol and total sulphydryl group content

Accessible free thiols and total sulphydryl group content in the flour and pasta samples were estimated by a colorimetric determination of the free SH groups, using a solid phase assay $NTSB^{2-}$, according to the method of Chan and Wassermann (1993). The determinations of accessible free thiols and total sulphydryl group were performed in triplicate.

2.6. Sensory analysis

Dry spaghetti samples were examined by a panel of 15 trained tasters (seven men and eight women, aged between 28 and 45 years). The panelists were selected in a preliminary session and were experienced in the products and terminology (ISO 11036, 7304). In these specific trials, panelists were asked to indicate color, homogeneity and resistance to breaking of uncooked spaghetti and elasticity, firmness, bulkiness, adhesiveness, color, odor and taste of cooked spaghetti. For the evaluation, a nine-point scale, where 1 corresponded to *extremely unpleasant*, 9 to *extremely pleasant* and 5 to the *threshold acceptability*, was used to quantify each attribute. On the basis of the above-mentioned attributes, panelists were also asked to score the overall quality of both cooked and uncooked samples, using the same nine-point scale (Padalino et al., 2013).

2.7. Cooking quality

The optimal cooking time (OCT) of pasta and the cooking loss (the amount of solid substance lost into the cooking water), were both evaluated according to the AACC approved method 66–50. The swelling index and the water absorption of cooked pasta (grams of water per gram of dry pasta) were determined according to the procedure described by Padalino et al. (2013). Three measurements for each sample were performed.

2.8. Statistical analysis

Experimental data were compared by one-way analysis of