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Starch digestibility and properties of fresh pasta made with semolina-based liquid sourdough

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ABSTRACT

The aim of this work was to develop an innovative formulation of fresh pasta, which combined semolina and liquid sourdough. Quality and shelf-life of pasta were monitored on unpacked fresh pasta and on pasta packed in modified atmosphere after pasteurization. The addition of sourdough and the pasteurization were responsible for a yellowness increase of pasta. After *in vitro* digestion of cooked pasta, a lower proportion of slowly digestible starch (SDS; 43.0 g/100 g) and a higher proportion of inaccessible digestible starch (IDS; 40.2 g/100 g) was found in sourdough pasta than the control (49.8 and 34.5 g/100 g of SDS and IDS), and in pasteurized pasta (44.0 and 39.3 g/100 g of SDS and IDS) than the fresh pasta (48.8 and 35.4 g/100 g of SDS and IDS). FT-Raman spectra of pasteurized sourdough pasta showed a higher level of retrograded starch, as indicated by the lower value (479.14 cm^{-1}) of the frequency of the band peaked at ~480 cm^{-1}, than the pasteurized control (479.47 cm^{-1}). Unpacked sourdough pasta could be stored for one week without mould growth, which on the contrary appeared in the control. The pasteurization was more effective in sourdough pasta, with the complete disappearance of the microorganisms.

1. Introduction

The research of innovative foods, with enhanced healthy properties and nutritional value is extremely timely. Sourdough fermentation is the oldest technology used in bread leavening, and in the last decade many bakeries have re-discovered the practice of using sourdough in bread making, probably because many studies have highlighted the beneficial effect of sourdough fermentation in bread, in terms of nutritional and healthy properties (Chavan & Chavan, 2011). The intake of sourdough bread reduces postprandial blood glucose and insulin response. The mechanism underlying this phenomenon is quite well understood (Fardet, Leenhardt, Lioger, Scalbert, & Rémésy, 2006) and it is explained with the presence of organic acids that slow the gastric empting and reduce starch accessibility to digestive enzymes. Besides this, a low glycemic index is obtained thanks to the compact structure of the sourdough bread crumb (Fardet et al., 2006). In bread making, the sourdough fermentation has shown to exert advantageous effects also against mould spoilage and the staling phenomenon (Chavan & Chavan, 2011), thus fulfilling the consumer expectation for additive-free products. At the end of their review Poutanen, Flander, and Katina (2009) observed that sourdough could be used to enhance quality of many more foods than so far has been done. Considering that Italy is the biggest producer and exporter of pasta, a great impact of any process innovation devoted to improve the nutritional value of pasta is clear. In the last decade new ingredients has been included in the formulation of pasta to enhance its nutritional properties and the effects have been reviewed by Rawat and Indrani (2015). Flour from different cereals, from legumes or bran from wheat, have been used to increase fiber and protein content; bran extracts from durum wheat (Laus et al., 2017) have been used to improve the antioxidant properties. Dietary fibers, known to exert beneficial effects for health, frequently are added to pasta to lower the glycemic index. Most of them derive from cereals or legumes, but other sources are used (Li, Zhu, Guo, Brijs, & Zhou, 2014; Rawat & Indrani, 2015).

To our knowledge the biotechnological exploitation of lactic acid bacteria (LAB) in pasta-making has been poorly investigated (Capozzi et al., 2012). In this paper the use of liquid sourdough as a functional ingredient to prepare fresh pasta and fresh pasteurized pasta has been studied. Physical, chemical, microbiological and nutritional characteristics of fresh pasta were evaluated, together with consumer preference.

Abbreviations: LAB, lactic acid bacteria; CF, control fresh pasta; SF, sourdough fresh pasta; CP, control pasteurized pasta; SP, sourdough pasteurized pasta; TTA, total titratable acidity; TBC, total bacterial count; OCT, optimal cooking time; SI, swelling index; TS, total starch; RDS, rapidly digestible starch; SDS, slowly digestible starch; IDS, inaccessible digestible starch; FWHH, full width at half height

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Fresh pasta is a highly perishable product, due to its high content of water, and for this reason organic acids are often added to pasta, with the aim to low pH value and guarantee a longer shelf life (Li et al., 2014). As organic acids are commonly produced by LAB metabolism, a shelf life study was conducted on unpacked fresh pasta, and on fresh pasteurized and packed pasta, to evaluate the possible use of sourdough as a new preservative to extend the shelf life.

2. Materials and methods

2.1. Liquid sourdough preparation

Saccharomyces cerevisiae (PCC1140 strain) and *Lactobacillus alimentarius* (PCC859 strain), both belonging to the microbial collection of Porto Conte Ricerche, were used to prepare the liquid sourdough. Strains were cultured at 28 °C, respectively, in liquid stirred YEPD medium (10 g/L yeast extract, 10 g/L peptone, 20 g/L glucose, pH 5.5) and in MRS modified medium. To prepare MRS modified medium 20 g of compressed yeast were dissolved in 100 mL of distilled water, sterilized for 15 min at 120 °C, centrifuged at 3890 × g for 15 min, and 15 mL of supernatant was added to each liter of MRS medium. After 24 h microbial cultures were centrifuged and the pellet was inoculated in a 1:1 ratio (g/g) semolina-water mixture, with a cell density of 10^8 colony-forming unit (cfu) per g of dough, and incubated at 28 °C for 6 h. Daily backslopping was done with a bioreactor GL MINI 25 (Esmach S.p.A., Grisignano di Zocco, Italy), mixing sourdough with semolina and water, to obtain a dough yield 200. Fermentation was carried out at 26 °C for 4 h, then the sourdough was refrigerated at 5 °C. Media and supplements were purchased from Oxoid (Oxoid, Basingstoke, England).

2.2. Pasta preparation

Commercial semolina was used for pasta and sourdough preparation. The characteristics of semolina were: moisture 12.2 g/100 g, ash 0.75 g/100 g, protein 13.8 g/100 g, dry gluten 11.6 g/100 g, all on a dry basis, gluten index 77 g/100 g, the alveographic configuration ratio P/L 1.5 and deformation energy W 131 $Jx10^{-4}$. Pasta was manufactured using a pasta maker (Dolly, La Monferrina, Moncalieri, Italy) equipped with a bronze die. The chosen shape of pasta was a small macaroni type, named "*gnochetti*". Four different treatments were tested: control fresh pasta (CF), control pasteurized and packed pasta (CP), sourdough fresh pasta (SF), sourdough pasteurized and packed pasta (SP). Control samples were produced by adding 30 mL of water to 100 g of semolina (wet basis). Sourdough pasta was produced by mixing semolina (700 g) with liquid sourdough (600 g). As 100 g of liquid sourdough contains 50 g of water, the amount of water on the weight of dough was always 30%. Sourdough (pH = 4.4, total titratable acidity (TTA) = 10 mL) contained ~10^7 cfu/g of yeast and ~10^5 cfu/g of LAB.

After production, CF and SF samples were stored at 4 °C at ambient atmosphere, using plastic trays (two trays for each treatment) covered with an aluminum foil, and analyzed at 0, and 6 days of storage. The pasteurization was carried out using a water bath at 97 °C. A single layer of pasta was positioned on a 4 mm stainless steel sieve, and left above the boiling water for 3 min into the covered bath, in order to achieve a lethality value $F_{70/10}$ of 50 min, (Zardetto & Dalla Rosa, 2007). The temperature in the core of the product was measured using a data logger with a penetration thermocouple (Micropack III, Mesa Laboratories Inc, Lakewood, USA), and $F_{70/10}$ values were calculated using the DataTrace Pro basic v1.2 software (Mesa Laboratories Inc, USA). After pasteurization the samples, 100 g per tray, were packaged according to Sanguinetti et al. (2011). Modified atmosphere packaging was performed with CO_2/N_2 at a 30:70 ratio (mL/mL) using a packaging machine (Reetray 250, Reepack Srl, Seriate, Italy). Six trays for each treatment were stored at 4 °C and analyzed at 0, 1 and 60 days of storage.

2.3. Chemical and physical analyses

Moisture of pasta was determined using the thermogravimetric analyzer Thermostep (Eltra GmbH, Haan, Germany) at 105 °C, and water activity (a_w) using an AQUALAB instrument (Decagon, Pullman, USA). TTA and pH were determined with an automatic titrator (Crison, Hach Lange, Barcelona, Spain), by suspending 10 g of sourdough or homogenized pasta (Ultra-Turrax Ika-T25, IKA-Werke GmbH, Staufen, Germany) in 100 mL of distilled water. After 30 min gently stirring, the pH was determined and sample was titrated to pH 8.5 with NaOH 0.1 mol/L. TTA was reported as mL of NaOH (0.1 mol/L) per 10 g of wet pasta. Color of pasta was determined with a CM-700d spectrophotometer (Konica Minolta, Osaka, Japan) using the CIE 1976 color space for lightness (L*), redness (a*) and yellowness (b*).

2.4. Microbiological analyses

Microbiological analyses of sourdough and pasta were performed after serial dilution of 10 g of product after homogenization in a Stomaker (BagMixer 400, Interscience, Saint Nom, France) with 90 mL of sterile solution (1 g/L of peptone in distilled water). Total bacterial count (TBC) was performed on plate count agar medium, incubated at 28 °C for 2 days. MRS modified agar, for LAB, and Rose Bengal Chloramphenicol agar, for yeast and mould, were used. MRS agar plates were incubated anaerobically (Anaerogen and Anaerojar System, Oxoid) at 37 °C for 48 h. Rose Bengal agar plates were incubated at 28 °C for 4 days. Media and supplements were purchased from Oxoid (Basingstoke, England). Fresh and pasteurized pasta, stored at 4 °C, the former under ambient air and the latter in modified atmosphere, were monitored for six days and for sixty days, respectively.

2.5. Sensory analysis

Pasteurized pasta was subjected to sensory evaluation in order to determine the preference of consumers, following the UNI ISO 5495 (2016). Sixty-eight consumers of fresh pasta (35 female and 33 male), aged between 27 and 52 years (α-risk = 0.01; β-risk = 0.20; Pd = 50%) were recruited in two sessions. Fifteen grams of cooked samples (CP and SP), identified with a three-digit code number, were served in random order at a temperature of ~40 °C. The assessors evaluated the samples at 12 a.m., before lunch, in a chamber free from environmental elements that could distort normal perception. Water was provided for mouth rising between the samples. The assessors were asked to indicate which sample was preferred, and if the preference was due to the consistence or to the taste.

2.6. Cooking quality

The optimum cooking time (OCT), cooking loss (grams of solids per 100 g of pasta as is basis) and swelling index (SI; grams of absorbed water per gram of dry pasta) were measured on pasta according to the AACC Approved method 66-50 (AACC, 2000).

The texture of pasta was evaluated at optimum cooking time with a TA.XTPlus Texture Analyzer (Stable Microsystems, Godalming, UK). The Texture Expert v1.21 program was used for data processing. A cutting test was carried out using a TA-44 Craft Knife probe. The maximum of the force (N) *versus* time (s) curve was taken into account.

2.7. In vitro digestion and analysis of digesta

Starch digestion and analysis of products was performed on pasta cooked to OCT, following the procedure of Danza et al. (2014). Glucose released was determined colorimetrically (530 nm) in digested samples, which were collected at 0, 20, 120, and 180 min, here after referred to

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