LWT - Food Science and Technology 64 (2015) 678–684

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Gluten-free fresh filled pasta: The effects of xanthan and guar gum on changes in quality parameters after pasteurisation and during storage

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ARTICLE INFO

Article history:
Received 30 April 2015
Received in revised form
5 June 2015
Accepted 16 June 2015
Available online 23 June 2015

Keywords:
Gluten-free pasta
Hydrocolloids
Sensory analysis
Shelf life

ABSTRACT

The effects of xanthan (XG) and guar gum (GG), used at 2 different concentrations (1.5 and 2.5%), upon changes in microbiological growth, chemical–physical and colour parameters of gluten-free (GF) fresh pasta filled with cheese following pasteurisation and during refrigerated storage was evaluated. The pasta was designed to be consumed after deep frying. Control wheat flour fresh filled pasta was also prepared to make comparisons with the GF samples. The pasteurisation treatment resulted in adequate microbial reduction and allowed a mould free shelf life of 14 days; the best microbiological results were obtained with GG at both concentrations. The GF dough showed greater adhesiveness compared to control samples, while the use of XG resulted in a more cohesive dough. Following pasteurization, the GG-supplemented pasta exhibited contemporary higher and lower a_w values for the dough and the filling, respectively, compared with XG samples. The XG pasta better retained moisture during storage, resulting in the inhibition of the development of crack fractures on the dough surface, which appeared on the GG samples after 7 days of storage. Both hydrocolloids strongly reduced the percentage of oil absorbed during frying with respect to control, while no sensory differences were detected between the 4 GF groups.

1. Introduction

Celiac disease is a chronic immune-mediated enteropathy caused by the ingestion of gluten contained in different cereals, such as wheat, barley and rye (Murray, 1999). Strict adherence to a gluten-free (GF) diet throughout a patient's lifetime is the only possible remedy at present. The presence of gluten is necessary to provide structure in most bakery products as well as pasta and its replacement still represents a widely studied topic (O'Shea, Arendt, & Gallagher, 2014). GF bakery products are developed by combining different GF flours, starches and ingredients that help to provide structure, such as hydrocolloids, proteins, emulsifiers and sourdough (Hüttner, Dal Bello, & Arendt, 2010; Marco & Rosell, 2008; Sciarini, Ribotta, Leon, & Perez, 2012). GF bread and other bakery products have received a vast amount of research attention compared to GF pasta, reflected in the vastly different number of scientific papers published on these different food products; indeed only very few papers have been published on GF pasta (Hager, Czerny, Bez, Zannini, & Arendt, 2013; Mastromatteo, Chillo, Iannetti, Civica, & Del Nobile, 2011; Padalino, Mastromatteo, Sepielli, & Del Nobile, 2011; Sanguinetti et al., 2011). Gluten containing fresh pasta may be formulated by adding eggs into the dough, which can be filled with a mixture of ground meat, cheese or vegetables to produce fresh filled pasta. To the best of our knowledge no study has been published to date on GF fresh filled pasta, which is developing an important niche market both in Italy and abroad.

Both the dough and the filling of fresh filled pasta present high water activity values, encouraging microbiological growth (mainly moulds) and, in turn, considerably limiting the shelf life of this specialty. In addition to growth of altering microorganisms, the risk of pathogen growth is also high in this product. Italian legislation therefore requires that suitable pasteurisation treatments are performed before fresh pasta is packaged and storage at the maximum temperature of 4 °C (DPR n. 187 of 9 February 2001).

Our laboratory has developed a GF fresh filled pasta that

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http://dx.doi.org/10.1016/j.lwt.2015.06.046
0023-6438/

presents similar dough characteristics to a gluten containing counterpart studied by our group some years ago (Sanguinetti et al., 2011). The basic formulation was optimised for dough kneading and sheeting and included rice flour, corn starch, milk proteins, animal fat, salt, water and one of two hydrocolloids, XG or GG, as structuring ingredients.

The aim of the present study was to check for changes in the quality parameters of fresh GF pasta, supplemented with either XG or GG and filled with fresh sheep's cheese, after pasteurisation and during cold storage, in order to have new data on the shelf life of the product.

2. Materials and methods

2.1. Raw materials

Rice flour, corn starch, milk proteins, GG and XG, used to prepare GF fresh pasta, were supplied by Chimab (Campodarsego, Italy). Animal fat (pork) was from Galbani (Milan, Italy) and salt from Lisal (Cagliari, Italy). Semolina, used to prepare fresh (gluten-containing) pasta for the control samples, was supplied by Molini Galleu (Ozieri, Italy). Fresh cheese for the filling, derived from the acidified curd of sheep's milk, was provided by F.lli Pinna Industria Casearia S.p.A. (Thiesi, Italy). Sunflower oil was used to deep fry samples (Carapelli, Firenze, Italy).

2.2. GF samples preparation

The fresh GF dough was obtained by mixing together equal amounts of rice flour and corn starch, then adding animal fat (20%, flour plus starch basis), milk proteins (5%) and salt (2%). To this basic formulation, either GG or XG hydrocolloids were added at one of two different concentrations (1.5 and 2.5%), generating four distinct pasta formulations: GG (1.5), GG (2.5), XG (1.5) and XG (2.5). Water addition was optimised to obtain non sticky dough, equal to approximately 50% of the weight of the flour plus starch. Ingredients were kneaded in a mixer (5KSM7990X, Kitchen Aid, St. Joseph, MI) for 2 min at speed 2, and 2 min at speed 4. The dough was then wrapped with a plastic film and put in a refrigerator at 4 °C for 24 h, finally it was passed through an artisan pasta machine (Sfogliatrice, Imperia, Moncalieri, Italy) to obtain 5 mm sheets of pasta dough. 120 mm diameter disks of fresh pasta were cut and 20 g of grated fresh sheep's cheese placed in the centre of one disk that was then covered with a second disk and sealed around the edges.

2.3. Control sample preparation

The fresh control pasta samples were prepared in our lab as follows: the dough was prepared by mixing semolina flour, animal fat (18.75%, flour basis, f.b.), water (31.25% f.b.) and salt (2.5% f.b.). The dough, filling and final product were processed using the same equipment and methodologies previously reported for control samples. The control samples were only compared with GF samples in relation to dough rheological measurements, sensory parameters and oil absorption during frying.

2.4. Pasteurisation and cooling

The product was pasteurised by injecting steam into a 3 m chamber (Custom, Italgi, Genova, Italy). A specific combination of temperature ($T = 91 \pm 1$ °C) and time (9 min) was used to achieve a sufficient lethality value F_{70}^{10} of 50 min, while maintaining the best external appearance of the pasta samples. Shortly after the pasteurisation treatment was complete, the pasta surface was dried using 2 fans that cooled the products down to 4 °C in 15 min in an air freezer (BSC 46, Bongard, Holtzheim, France).

2.5. Calculation of the F_{70}^{10} value

A data logger penetration thermocouple inserted into the coolest point of the product permitted us to obtain a penetration heat curve and to calculate the F_{70}^{10} value (Micropack III, Mesa Laboratories Inc, Lakewood, CO, USA). The temperature acquisition time was set to 10 s and data were downloaded onto a computer and processed using specific software (Data Trace RF, Version, Mesa Laboratories Inc, Lakewood, CO, USA).

2.6. Product packaging and storage

The cooled samples were arranged onto polystyrene trays (two samples per tray), which were hand wrapped with 9 μm polyvinylchloride film characterised by the following gas transmission rates (manufacturer's data): O_2, 5000 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C; CO_2, 38,000 $cm^3\ m^{-2}\ 24\ h^{-1}\ bar^{-1}$ at 23 °C: water vapour, 169 g m^{-2} 24 h^{-1} at 23 °C. The trays were stored at 4 °C and sampled for analysis at 0, 7, 14, and 21 days. A total of 40 trays were prepared for each of the four pasta groups investigated (GG and XG at 1.5 and 2.5%).

2.7. Samples analysis

2.7.1. Dough rheological measurements

Texture profile analysis (TPA) was used to determine dough machinability. Briefly, a TA.XT *plus* texture analyser (Stable Micro Systems, Godalming, UK) equipped with a 30 kg load cell and fitted with a 50 mm diameter probe (P/50) working with a 75 s waiting period and 60% compression was used (Collar, Conte, Fadda, & Piga, 2014). A penetration test was also carried out to measure the resistance to penetration, as reported by Sciarini et al. (2012). A 5.0 mm aluminium probe compressed the dough at a rate of 1.5 mm s^{-1} until disruption of the surface structure was achieved. The penetration force (N) was fixed as the value corresponding to the intersection of the two straight lines in the curve. Stress relaxation tests were carried out according to Fois et al. (2012). The percentage of relaxation was set as the percent ratio between the force registered after 35 s and the maximum registered force.

2.7.2. Microbiological analysis

Ten grams of each sample were homogenised in 90 mL sterile 0.1% peptone solution for 2 min in a Stomaker Lab blender 80 (PBI, Milan, Italy). Decimal dilutions were prepared using sterile 0.1% peptone solution and plated on specific media to enumerate microbial groups. Plate Count Agar medium (Oxoid, Milan, Italy) was used for total microbial counts (TMC), and samples were incubated at 32 °C for 48 h. Mannitol Salt Agar (Oxoid, Milan, Italy) was used to detect *Staphylococci* after incubation for 48 h at 37 °C. *Clostridia* were detected using Differential Reinforced Clostridial Medium (Merck, Milano, Italy); before incubation at 30 °C for 7 days, tubes containing dilution samples and medium were treated at 80 °C for 10 min to destroy the vegetative cells and remove dissolved oxygen. Enumeration was performed using the Most Probable Number method (MPN). Total coliforms were detected on Violet Red Bile Agar (Oxoid, Milan, Italy) after incubation at 37 °C for 48 h. To detect aerobic spore-forming bacteria (ASFB), Nutrient Agar (Oxoid, Milan, Italy) was used and plates were incubated at 30 °C for 48 h; all vegetative forms were previously destroyed by pasteurising sample dilutions at 80 °C for 10 min. Moulds and yeasts were detected on Rose Bengal Chloramphenicol Agar incubated at 25 °C for 4 days.