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Bread-making performances of durum wheat semolina, as affected by ageing

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ABSTRACT

The present study addresses the influence of ageing on the bread-making performances of durum wheat semolina by bread image analysis. Bread loaves were produced from semolina samples stored in 4 different packaging materials for up to 150 days. Sampling and bread-making trials were performed every 15 days. Results showed that ageing does affect durum wheat semolina bread-making performances, highlighting that storage time, rather than the type of packaging material, is the main factor determining quality changes in the final bread samples. In particular, a change in the crust colour parameters and a reduction of the bread slice area and height by 20–35% were observed with increasing semolina storage time, along with a slight increase of crust % area. The change in farinographic parameters of dough suggests that the observed reduction of technological quality might be due to increased stiffness and reduced extensibility of gluten occurring in aged semolina. Unlike common wheat flours, which usually improve their technological features during ageing, durum wheat semolina is negatively affected in its quality by storage. The study highlights the importance of considering bread-making performances among the quality parameters to be taken into account for the shelf life evaluation of durum wheat semolina.

1. Introduction

Durum wheat semolina is mostly used for the preparation of pasta and couscous, however in the Mediterranean area it is also used to make bread. Compared with common wheat cultivars, durum wheat ones generally exhibit inferior bread-making performances as measured in terms of loaf volume and crumb grain characteristics (Boggini et al., 1995; Hareland and Puhr, 1999; Peña et al., 1994). However, it has been reported that bread obtained from durum wheat flours is characterised by relatively slow staling and, consequently, a longer shelf life (Quaglia, 1988) due to the high water-binding capacity of durum wheat flour (Boyaçioglu and D'Appolonia, 1994). The addition of durum wheat flours has been found to be useful for improving the bread-making properties of poor quality common soft wheat and for extending the shelf life of the derived products.

Several studies have focused on the study of bread quality using image analysis as the main investigation tool (Brescia et al., 2007; Gallo et al., 2010; Grillo et al., 2007; Magdić et al., 2002). Bread quality is affected by several factors, such as the flour nature (Boggini et al., 1995; Baardseth et al., 2000; Baiano et al., 2009; Gallo et al., 2010), the milling techniques and bread-making process (Baardseth et al., 2000; Boggini et al., 1995; Sapirstein et al., 2007), yeast type, water content of dough and the use of enzymes and other additives (Ozge Ozkoc et al., 2009; Ribotta et al., 2004; Roccia et al., 2009).

Physico-chemical changes during storage of flour can affect their technological properties. Stored flours either release or absorb moisture until atmospheric equilibrium is reached. Protein, crude fat, free amino acids, proteolytic activity, diastatic activity and damaged starch decrease with an increase in the length of storage (Sur et al., 1993).

Ageing of flours can affect the gluten fraction of flours, with important consequences on their bread-making performances (Wang and Flores, 1999). It is confirmed that gluten increases its strength during storage, due to gluten protein oxidation which relies on the formation of S–S bonds. However, the effect of such changes is controversial, essentially depending on wheat genotype. Changes in gluten would result in the improvement of bread-making properties of most wheat flours, so that ageing is often considered as a tool for improving bread-making properties of flours (Wang and Flores, 1999). On the other hand, studies

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performed on strong flours demonstrated a substantial decrease of their technological properties, especially if flour is stored at high temperatures (Chen and Schofield, 1996; Kozmin, 1935; Mangels, 1924; Miś, 2003).

The study of the shelf life of a product relies on the choice of quality attributes, which depends on the use and destination of such product and on expectations of users. In the case of flours and semolina, important quality parameters are the bread-making performance, i.e. the capacity to yield bread loaves with good volume and rheological properties.

To our knowledge, very little information is available on the effect of durum wheat semolina ageing on bread-making performance. The aim of the present research was to assess the influence of packaging type and storage time of durum wheat semolina on the physical characteristics of bread by image analysis.

2. Material and methods

2.1. Packaging materials and semolina sampling

Freshly-produced durum wheat semolina, coming from a unique batch, was bought from a local mill (Salvatore Bucolo s.r.l., Misterbianco, CT, Italy). Semolina was divided into 4 batches and packed in 500-gram bags made with different materials. Paper bags were used as received and were identical to the ones commonly used for marketing semolina. The other bags were shaped with the same dimensions as the kraft paper (P) ones (13 cm × 12 cm × 4 cm) from reels of test materials: cast polypropylene (CPP), bioriented polypropylene + cast polypropylene (BOPP + CPP) and paper + cast polypropylene (P + CPP). Three sealings were applied, one for each short side (top and bottom) and one on the back side of the bags, using an industrial sealing machine. Packaging materials were kindly supplied by Rotocalco Mediterranea (Siracusa, Italy). The materials tested with their thickness and water vapour transmission rate (WVTR) values are reported in Table 1.

Semolina samples were stored at 30 °C and 49% relative humidity. Two semolina samples (replicates) for each of the four packaging materials were withdrawn at 15-day intervals, to carry out farinographic tests and bread-making trials.

2.2. Rheological tests and bread-making

Semolina was subjected to farinographic test by a Brabender Farinograph (Farinograph-E Brabender GmbH & Co. (Duisburg, Germany).

Bread dough was obtained by mixing 250 g semolina, water as a function of the farinographic test, 6.3 g baker's yeast, 5 g salt. Dough was divided in parts, shaped in experimental aluminium tins for sandwich-bread, let leavening at 30 °C for 40 min, 70% R.H. and cooked in a Polin mod. Wind Pierre experimental oven (Verona, Italy). Bread samples were baked at 250 °C for 30 min, cooled and sliced for image analysis. At each sampling time, three bread loaves were produced from each of the two replicate semolina packages.

Table 1
Packaging materials tested, with relative water vapour transmission rate (WVTR), density (for paper) and thickness values (Licciardello et al., 2010).

Material	WVTR	Density/thickness
P	8482 g/(m^2 24 h)	30 g/m^2
CPP	13.18 g/(m^2 24 h)	30 μm
BOPP + PP	3.06 g/(m^2 24 h)	25 μm + 30 μm
P + CPP	1.19 g/(m^2 24 h)	30 g/m^2 + 30 μm

2.3. Image analysis of bread slices

Using a Twain controller (ScanWizard, Microtek, Denver, CO), images of three slices for each bread loaf were acquired and digitalized with a flatbed scanner (ScanMacker, 9800XL, Microtek. Denver, CO) at 200 dpi resolution in RGB colour model. The obtained images were digitized and stored in TIF format. Before the acquisition of the sample images, the scanner was calibrated for color matching, following the protocol of Shahin and Symons (2003), as suggested by Venora et al. (2009). The KS-400 V3.0 image analysis library (Carl Zeiss, Vision, Oberkochen, Germany) was used to develop a specific macro (Grillo et al., 2007) able to execute the automatic measurement of images (Fig. 1). This macro allowed measurement of various parameters related to the slice colour and morphology. Two slices from each of the six bread loaves (three loaves were obtained from each of the two semolina package) were analysed.

3. Results and discussion

3.1. Farinographic data and bread-making trials

Water absorption is a common farinograph parameter and allows measurement of the exact amount of water required by flour or semolina to reach a specified value of dough consistency, which conventionally corresponds to 500 Brabender Units (BU). Water absorption of semolina packed in all of the four packaging materials, increased slightly (data not shown), however such increase was simply due to the loss of moisture during storage, and a significant correlation between the two parameters was found ($r = 0.690$, $n = 44$, $p \leq 0.001$).

Dough stability (Fig. 2) increased slightly until 60 days of storage, and more rapidly in the second part of the shelf life test, with the only exception of the P sample, reaching values around 18, 15 and 10 min for CPP, P + CPP and BOPP + CPP, respectively.

Similarly, the loss of consistency after 12 min (Fig. 3) remained constant until 60 days of storage, and decreased sharply during the second part of the shelf life test, with the only exception of P samples, which maintained higher values (which means lower stability). Loss of consistency and dough stability are highly correlated ($r = -0.939$, $n = 44$, $p \leq 0.001$).

The three loaves obtained from each semolina package showed a very low coefficient of variation for the geometric parameters (slice area and height), averagely 2.40%, and slightly higher coefficients for the crust color parameters (ranging from 10.8 to 12.8). Such values did not differ through the duration of the research (5 months).

Bread loaves produced from the two replicate semolina packages, showed low coefficients of variation for what concerns slice area and height (3.5 and 3%, respectively), crust % area (6.8%), and color parameters (variation ranging from 12.1 to 14.7, for the respective parameters considered). The low variation highlighted the high repeatability of bread-making trials, which represents a solid base for the further data analysis.

3.2. Image analysis

Image analysis was effective in determining bread quality parameters, such as color and morphology of slice. Results are hereafter divided into two sections: data relative to crust colour and geometry, and data concerning the slice geometry.

3.3. Crust color and geometry

Results for crust (Table 2) were in agreement among the different packaging materials. In particular, the following color