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Development of a standard test for dough-making properties of oat cultivars

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ABSTRACT

Bread is consumed all over the world. However, so far, production of large volume bread is only possible with wheat. Alternatives, such as oats, are less suitable but this is partly due to the lack of knowledge about their functionality for other purposes than porridge, which is their most common use. Existing standard tests for the dough making characteristics of wheat flour are not suitable for oat flour, hampering research to optimize oats for bread-making purposes. We therefore set out to develop a test to evaluate oat in relation to mixing and dough making properties using wheat as a model. It was possible to reproduce the profile of various qualities of wheat flour using mixtures of oat flour and gluten in different proportions. Our standard test was based on a dough system composed of 87.2% oat flour and 12.8% gluten and it presented similar properties to a wheat flour with regard to resistance to extension. This dough system was sensitive and reliable (coefficient of variation lower than 10%) for detecting differences among oat cultivars, and it can be used to screen oat varieties and individual oat components in relation to relevant properties for bread-making purposes.

1. Introduction

Bread is an important staple especially in European countries with wheat (*Triticum aestivum*) bread being most popular among consumers. There is an increasing demand for new products for different target groups that should meet different quality criteria related to texture, taste, nutrition, and health. Oat is an interesting alternative for people with celiac disease (Pulido et al., 2009; Londono et al., 2013), or people who for example like to benefit from the health -related compounds present in oat (Butt et al., 2008).

The inclusion of oat in the daily diet is encouraged because it contains components that have been associated with health benefits, notably beta-glucans, that help to decrease cholesterol and glucose in the blood (Butt et al., 2008; Jenkins et al., 2002). High blood cholesterol is a major risk factor for coronary artery disease which is one of the main causes of death in Western countries (Butt et al., 2008). Beta-glucans are considered as a functional component for prevention of cardiovascular diseases and of type II diabetes (Jenkins et al., 2002).

People that suffer from celiac disease, a chronic disorder caused by ingestion of gluten proteins that affects about 1% of the Western population, should stick to a long-life gluten-free diet. But gluten free breads – and, for that matter, gluten free products in general-, have an inferior quality compared to those made of wheat flour (Hager et al., 2012). In a comparison of different gluten-free formulations, loaves made of wholegrain oat flour presented similar specific volume to loaves made of wholegrain wheat flour, the loaf specific volumes were 2.40 for oat bread and 2.62 ml/g for wheat bread (Hager et al., 2012). However, despite their similarity, these volumes are considered of inferior quality in comparison to standard white wheat breads, which have specific volumes between 3.5 and 4 mL/g (Belitz et al., 2004).

Gluten-free bread making is normally based on low viscosity systems known as batter systems. They account for a water addition ranging between 95 and 120% w/w (Hager et al., 2012; Huttner et al., 2009). This approach has been used to test bread-making performance of commercial oat flours and oat cultivars, and differences

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have been reported using the same formulation for all of them: 100% oat flour, 120% water, 1.75% salt, 1% sugar, and 2% dried yeast (Hüttner et al., 2010a,b; Hüttner et al., 2011). The largest differences among oat cultivars regarding bread-making were observed in crumb texture while no significant differences in loaf specific volume occurred (about 1.5 ml/g). Additionally, various technologies have been tested to improve quality of oat bread by treating the batters with high pressure (Huttner et al., 2009), adding enzymes (Renzetti and Arendt, 2009; Renzetti et al., 2009), hydrocolloids (Huttner et al., 2010a,b), or bacteria (Moore et al., 2007).

The baking quality of wheat is mainly determined by gluten content and its composition (Bushuk, 1998). Gluten proteins confer the unique viscoelastic properties to wheat dough which are essential for gas retention. Of all gluten proteins the high molecular weight (HMW) glutenins contribute most to the elastic properties of wheat dough and to the loaf volume (Bushuk, 1998). The lower quality of oat bread compared to wheat bread has been mainly attributed to the absence of gluten proteins in oat. Normally, when people use the term ‘oat bread’, they refer to composite breads made of mixtures of oat meal and wheat flour in various proportions. So far, the maximum amount of oat meal that has been used in a composite oat/wheat bread without compromising texture is 51% together with an adjustment of the formulation and the baking process (Flander et al., 2007).

From a practical point of view, it would be more convenient for bakers to use a dough system instead of a batter system to make oat bread because batters are sticky and difficult to handle, but also to avoid the use of thickening agents on which batter systems rely because they are costly. There is however a gap of knowledge concerning the relevant functional aspects of oat flour and the technology required for making oat bread. There are no standard parameters to test oat flours using dough systems that can fulfil the same functions as the parameters that exist for wheat flour. The Farinograph and extensibility parameters to test bread quality of wheat flours are well defined, but cannot be used as such for oat flour. Therefore, we aimed to develop a standardised dough system to test the intrinsic technological properties of oat cultivars and to be able to study the functionality of different oat components on the bread-making properties. Our approach was based on replacement of a fraction of oat flour with vital gluten to determine if it was possible to reconstruct, partly or completely, typical wheat-like properties, using the maximum amount possible of oat flour as basis. The standard system proposed does not reflect the final oat bread aimed for with respect to optimal quality, but only forms a first step towards good quality oat bread. The standard system simply serves an analytical purpose in order to fill the knowledge gap regarding the effects of components of oat.

2. Materials and methods

2.1. Flours

For the experiments, we used commercial oat meal (De Vlijt, Wageningen, the Netherlands), wheat flour – which we will refer to as wheat flour “C”-, and its gluten fraction (provided by Cargill, the Netherlands), and commercial wheat Patent flour (C1000, the Netherlands). As the texture of oat meal was visibly coarser than the texture of wheat flours, the size of the particles in 50 g of oat meal was characterized using a series of sieves of 0.500, 0.300, 0.250, 0.180, 0.150, and 0.071 mm opening. We decided to use only the fraction that passed through the 0.250 mm sieve to eliminate possible detrimental effects of large particles on the gluten network (Noort et al., 2010). This fine fraction was packed in plastic bags, sealed and stored in the freezer until use. This fine fraction (<0.250 mm) is what we refer to as oat flour in this study.

Moisture content of oat meal, oat flour, and wheat flour was calculated using the AACC method 44-15A. Nitrogen was determined by combustion (AACC approved method 46–30) using a NA 210 nitrogen and protein analyser (ThermoQuest, Ronado, Italy) to calculate the protein content, using a factor of 6.25. Total starch was quantified using the AACC method 76–13, and β-glucan content by the AACC method 32–23.

Once the standard test was developed using the sieved fraction of commercial oat meal, grains of 10 oat cultivars (DLO, the Netherlands) were put in a 0.5 m^3 steel container to undergo the kilning process. First, a grain layer of three cm was placed in the container and steamed for 3 min at 100 °C. Then, the grains were let cool down for 30 min and placed in a drying oven at 85 °C overnight. The grains were milled at 8000 rpm (Hosokawa Alpine D-86199, Augsburg), and sieved in the same way described for oat meal to remove the bran particles. The fraction that passed through the <0.250 mm sieve was used to compare their extensibility properties to test the sensitivity of the standard dough system to detect differences. The composition of the oat varieties is presented as Supporting information (S1).

2.2. Making a dough system

We prepared dough using pure oat flour and mixtures of oat flour and vital gluten in different proportions in a total weight of 10 g (14% moisture). In total, seven flours were used to make dough: pure oat flour and mixtures in which a fraction of oat flour was replaced with 0.08, 0.16, 0.32, 0.64, 1.28, and 2.56 g of gluten. The wheat flour “C” that was used as source to extract the gluten was used as control for its functionality in the mixtures; dough made of commercial wheat Patent flour was included just for comparison. 2% (mixture basis) NaCl was added to all flours to prepare a dough according to the method 54–21.

A Micro-Farinograph (Brabender instruments, Mod.-No. 8110) was used to determine the amount of water that each flour required to get a consistency of 500 BU, which is the standard consistency to test quality of wheat flour, and to establish the mixing time required to reach the peak consistency (dough development time). First, we determined the water absorption that each of the flours required. Then, we proceeded to prepare the dough using the Micro-Farinograph. The dough was allowed to relax in a plastic container within an incubator for 20 min at 30 °C and a constant relative humidity of 85%. After relaxation the dough was homogenized by hand and pressed between two oiled grooved forms to make dough strips. These strips were let to relax again for 40 min within the grooved bases in a plastic container at 24 °C and constant relative humidity. Subsequently, its maximum extensibility (mm) and resistance to extension (*g*) were measured using a Texture Analyser fitted with the SMS/Kieffer Extensibility Rig (Stable Micro systems). The standard settings for wheat flour were used according to instructions of manufacturer:

Mode: Measure force in tension
Option: Return to start
Pre-test speed: 2.0 mm/s
Test speed: 3.3 mm/s
Post-test speed: 10.0 mm/s
Distance: 120 mm
Trigger force: 5 g
Data acquisition rate: 200 pps

2.3. Standardisation of consistency and mixing time

Initially we selected a mixture of oat flour and gluten that presented intermediate values of maximum extensibility, resistance to