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Structural role of fibre addition to increase knowledge of non-gluten bread

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ABSTRACT

Dietary fibres can play a significant role in GF bread development. Besides their well documented health benefits, dietary fibres can improve the texture, sensory characteristics and shelf life of baked products, due to their water binding capacity, gel forming ability, fat mimetic, textural and thickening effects. Dietary fibres from different sources are discussed in this paper and their role in GF products' making is analysed. The sources of fibres vary: flours, fruit and vegetable processing by-products, isolated ingredients, seeds or mixtures of all of these can be used. Fibres improve the structure and result in dense crumb porosity. Tasty products with soft crumb can be produced, and there are many perspectives in further products development.

1. Introduction

Celiac disease (CD) is an autoimmune enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. It is considered one of the most common human genetic disorders, with a prevalence of 1% of the general population worldwide (Lionetti et al., 2015). At present the only safe and effective treatment for CD patients is a lifelong adherence to a gluten-free (GF) diet. Following a GF diet may be difficult for CD patients, since the quality of available GF products in the market is usually low compared to their wheat counterparts (Ronda et al., 2013). Gluten is the main structure-forming protein in wheat flour, responsible for the elastic and extensible properties of bread dough, required for producing high quality baked goods. Wheat bread dough is capable of retaining the gas—CO_2 produced during fermentation, thanks to its viscoelastic properties attributed to the gluten protein presence, yielding voluminous and palatable end-products (Romano et al., 2007). On the other hand, the absence of gluten for the production of GF breads results in a liquid batter rather than a dough, unable of retaining the maximum gas produced during fermentation, leading to an unstable batter and resulting in end-products of low quality characterized by a poor mouthfeel, a dry and crumbly crumb, poor flavour and high staling rate (Arendt et al., 2002). A major challenge for cereal technologists and bakers is the research for gluten mimic substances for manufacturing GF breads with similar quality characteristics to wheat breads.

Dietary fibres can play a significant role in GF bread development. Besides their well documented health benefits, dietary fibres can improve the texture, sensory characteristics and shelf-life of baked products, due to their water binding capacity, gel forming ability, fat mimetic, textural and thickening effects (Phimolsiripol et al., 2012). A lot of studies concerning the use of cereal gluten-free flours, fibre-rich seed flours or isolated fibres with a high purity level are available for GF bread production. Elaboration of GF bread with pseudocereal flours or seed flours such as carob flour and chestnut flour exhibited increased specific volume, a soft and homogeneous crumb and reduced staling rate (Alvarez-Jubete et al., 2010; Demirkesen et al., 2014; Tsatsaragkou et al., 2012). Similar results were reported for GF breads containing purified fibre preparations such as inulin, fructo-oligosaccharides or isolated cereal fibres (Capriles and Areas, 2013; Korus et al., 2006; Sabanis et al., 2009; Ziobro et al., 2013). More specifically Korus et al. (2006) reported the increase of volume and decrease of crumb hardness of a GF bread containing inulin. Sabanis et al. (2009) indicated that the addition of dietary fibre from maize gave GF breads with significantly higher loaf volume and crumb softness compared to the control non-fibre GF bread. At the same time, dietary fibre addition at 3% flour basis improved the sensorial acceptability of GF bread compared to control.

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Moreover, there is an increased awareness of celiac disease, which has driven interest in the gluten-free market. The growth of the market has also been fuelled by consumer health trends such as weight management and their needs for simpler, less processed foods. The result was an explosion in a gluten-free market over the past years with sales of gluten-free food and beverages been in 2012 approximately 5 fold greater than those in 2004 that were $580 million. The market presented an annual growth rate of 30% from 2006 to 2010 (Pszczola, 2012). The addition of fibres in GF products can further reinforce the market.

This review discusses the role of dietary fibres as structure enhancers in GF leavened breads. Proper knowledge of the relationships between DF structure and functionality will help understanding the interactions of a complex fibre-bread dough system for obtaining GF bread of high quality.

The types of fibres that are presented in this review are showed in Table 1.

2. Flours or seeds with a ratio of soluble/insoluble fibres

2.1. Pseudocereals

Amaranth, quinoa and buckwheat are referred to as pseudocereals, as their seeds resemble in function and composition those of the true cereals, although they are dicotyledonous plants as opposed to most cereals (e.g. wheat, rice, barley) which are monocotyledonous.

Dietary fibre content is significantly higher in buckwheat seeds (29.5% dry basis) in comparison to amaranth (20.6% dry basis) and quinoa (14.2% dry basis), which have fibre levels comparable to those found in common cereals (Alvarez-Jubete et al., 2009). According to Alvarez-Jubete et al. (2010) substitution of rice flour with each one of the three pseudocereals at 50% in a GF bread formulation resulted in increased bread volumes, for buckwheat (1.63 mL/g) and quinoa (1.4 mL/g) breads compared to control bread (1.3 mL/g). In addition, breads containing pseudocereals exhibited a significantly lower crumb hardness compared to control bread during the 5 days of storage. Similar results were obtained in a more recent study for the effect of corn starch substitution by buckwheat flour in a GF bread formulation. Wronkowska et al. (2013) reported that the substitution of corn starch up to 40% by buckwheat flour resulted in breads with increased loaf volume from 2.34 mL/g to 3.15 mL/g for control sample and sample containing 40% buckwheat flour respectively.

Mariotti et al. (2013) used dehulled and puffed buckwheat flour for improving GF breads mixtures commercially available on the market. Substitution of up to 40% buckwheat flour to the two commercial mixtures improved the leavening characteristics of the dough and subsequently the final bread quality. As a result the specific volumes of commercial mixtures containing buckwheat flour were significantly higher to controls especially with the presence of hydroxypropyl methyl cellulose (HPMC). A mixture of dehulled and puffed buckwheat flours at a ratio of 35/5 and 0.5% HPMC reduced diffusion and loss of water from bread crumb, resulting in a softer GF bread crumb and a slower staling rate during storage.

The studies of Wronkowska et al. (2013) and Mariotti et al. (2013) reveal the stabilizing effect of buckwheat on GF bread batter, indicated by the enhancement of dough development and gas holding capacity during fermentation, which can be attributed to the increased water holding capacity of buckwheat flour, due to buckwheat high dietary fibre content, compared to other starches mainly used for GF bread production (corn or potato). The addition of ingredients with increased water holding capacity in GF dough could lead to an increase in the viscosity of the dough, enhancing its viscoelastic properties, a prerequisite for the production of GF bread with increased specific volume and a soft and fluffy crumb. Incorporation of high percentages of buckwheat flour in GF bread formulations (40–50% flour basis) was found to retain bread crumb soft during storage and was ascribed to the presence of natural emulsifiers in buckwheat flour. Emulsifiers form complexes with amylose, thus limiting starch swelling during baking and leaching of amylose, decreasing starch retrogradation phenomena, responsible for the hardening of bread crumb (Alvarez-Jubete et al., 2010; Wronkowska et al., 2013).

In a recent study of Elgeti et al. (2014) quinoa white flour was used to replace a GF control bread recipe containing rice and corn flour at 40–100% substitution level. Increasing the substitution amounts of quinoa flour to GF bread increased bread specific volume and simultaneously increased crumb elasticity and decreased crumb hardness. GF bread containing 100% quinoa flour exhibited a specific volume of 2.19 mL/g, which approaches the value of a standard wheat bread (2.36 mL/g). The authors reported that quinoa flour is suitable for increasing the volume of a GF bread, due to its inherent substrate availability for starch hydrolysing enzymes, compared to rice and corn flour, although the mechanism of gas cell stabilisation during fermentation in quinoa bread is still unknown.

Pseudocereals could be used for the production of GF breads with a better crumb structure, improved porosity and lower crumb hardness than typical GF breads, either by reducing the diffusion and loss of water due to their high water holding capacity or due to reduction of starch swelling or even due to their substrate availability for starch hydrolysing enzymes.

2.2. Wholegrain cereal flours

A wide variety of dietary cereal fibres have been used for the

Table 1
Types of dietary fibres used for GF bread development discussed in this review.

Raw materials with a ratio of soluble/insoluble fibres	Isolated fibres or commercial formulations	
Flours or seeds	Insoluble fibres	Soluble fibres
Wholegrain cereal flours	Oat	β-glucan
Pseudocereals	Bamboo	Psyllium
Fruit and vegetable by-products	Potato	Hydrocolloids
Carob	Pea	Prebiotics
Chia	Rice bran[a]	Rice bran[a]
Acorn	Wheat	
Chestnut	Maize	
	Barley	

[a] The authors used three commercial rice bran formulations mainly insoluble and one rice bran formulation totally soluble (Phimolsiripol et al., 2012).

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