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Current and forward looking experimental approaches in gluten-free bread making research

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ABSTRACT

Research efforts on gluten-free bread making have rapidly increased during the last decade. A lot of different approaches are being used to improve the quality of these products. The techniques used in gluten-free bread making research vary widely. This review focuses on the methodological aspects of gluten-free bread making research and extracts relevant data from all Web of Science peer reviewed research articles on gluten-free bread published from 2010 to date. Recipes and methodologies are grouped by (main) starch source and list other ingredients, additives and treatments used. The focus lies on the experimental setups typically used to analyze batter/dough and end product. Small deformation rheological measurements are typically performed on gluten-free batter/dough, along with several other batter/dough properties, but there is no clear link between these characteristics and the bread quality which typically is determined by volume and texture analysis or sensory evaluation. Some more recent techniques that have already been used on wheat bread or other bakery products are discussed as well. Their application in gluten-free bread making research may help extend the current knowledge.

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1. Introduction

Gluten proteins are the main storage proteins in wheat, and are responsible for the visco-elastic properties of wheat flour dough. People who suffer from coeliac disease, an intestinal intolerance to the storage proteins of wheat (i.e. all *Triticum* species), rye and barley (and sometimes oats), need to exclude these from their diet. While consumption of pure oats is safe for most coeliac patients, it is considered a gluten containing cereal in many countries because it is often contaminated with gluten containing cereals. Not only

coeliac disease patients, but also people who suffer from non-coeliac gluten sensitivity and an increasing share of consumers who avoid gluten for lifestyle reasons follow a gluten-free diet. Whether or not linked to coeliac disease or other gluten-related disorders, gluten-free diets attract a lot of attention in the media nowadays. The market of gluten-free products grows and enormous efforts are underway to enhance their quality. Literature has described the lack of cohesiveness and elasticity of gluten-free batters/doughs. They are more difficult to handle than wheat flour dough and have poor gas holding capacity. The end products have a low volume, a crumbly texture, pale color, poor flavor and firm rapidly.

2. Peer-reviewed literature on gluten-free bread making is limited

The use of gluten-free ingredients such as alternative flours, starches, hydrocolloids, proteins, enzymes, lipids, pseudocereals, and sourdough have been extensively reviewed (Alvarez-Jubete et al., 2010; Anton and Artfield, 2008; Arendt et al., 2007; Capriles and Arêas, 2011, 2014; Comino et al., 2013; Deora et al., 2014; Falade and Akingbala, 2011; Gallagher et al., 2004; Gobetti et al., 2007; Houben et al., 2012; Huttner and Arendt, 2010;

Abbreviations: ¹H NMR, proton nuclear magnetic resonance; 2D, two-dimensional; ADA, acetylated distarch adipate; CLSM, confocal laser scanning microscopy; (C)MC, (carboxy)methylcellulose; DAG, diacylglycerol; DATEM, diacetyl tartaric acid ester of mono- and diglycerides; DSC, differential scanning calorimetry; ERO, electrical resistance oven; EWP, egg white powder; FOS, fructooligosaccharides; GI, glycemic index; HACS, high amylose corn starch; HDP, hydroxypropyl distarch phosphate; HPMC, hydroxypropyl methylcellulose; IR, infrared; LAB, lactic acid bacteria; LBG, locust bean gum; MAG, monoacylglycerol; ML, Mixolab; MRI, magnetic resonance imaging; RVA, rapid visco analyzer; SEM, scanning electron microscopy; SPI, soy protein isolate; SSL, sodium stearoyl lactylate; TD, time domain; TGA, thermogravimetric analysis; TGase, transglutaminase; TPA, texture profile analysis; WP, whey protein.

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Kulamarva et al., 2009; Matos and Rosell, 2015; O'Shea et al., 2014; Ohimain, 2015; Omary et al., 2012; Rahaie et al., 2014; Wolter et al., 2014d; Zannini et al., 2012).

A literature search on the topic “gluten-free bread” in Web of Science in April 2015 resulted in a list of 655 articles. A critical examination of the titles and abstracts was done to exclude all papers on gluten detection, quantification and detoxification and those only describing experiments on wheat products. Fig. 1 shows the distribution in time of the 399 remaining articles concerning gluten-free bread with an estimate of the number of publications in 2015 (shown in grey) based on the number of publications during its first quarter. Since 2007 more than ten research articles are published every year. A stepwise increase is seen with approximately 30 articles published in 2008 and 2009 and approximately 50 each year from 2010 to 2013. In 2014 a steep increase is seen with 70 articles published that year. This steep increase seems to continue in 2015 (based on the estimate). Capriles and Arêas (2014) noticed a similar trend after performing a literature search on “gluten-free bread” up to the end of 2013. They found a slightly smaller amount of articles on gluten-free bread, probably due to the use of stricter search criteria.

A literature search on the topic “wheat bread” performed on the same day gave approximately 4800 articles of which more than 65% were published before 2010 while for “gluten-free bread” only 28% of the total number of publications were from before that date. A steep increase is seen in the number of articles on wheat bread from 2006 (approximately 160) to 2008 (approximately 300). Since 2008 the number of publications per year on wheat bread is rather constant.

Considering that all research papers on wheat bread deal only with one starting material, while in the research papers on gluten-free bread over different 20 origins of flours and starches are described, the number of papers on gluten-free bread from one flour or starch source is even more limited. Furthermore, as for wheat bread, there is wide variety of bread types based on regional habits, ranging from French-style bread, Brazilian cheese bread, Middle Eastern flat bread, Indian chapatti bread to West-European and North-American sliced bread.

3. Methodological aspects of gluten-free bread making research

This review takes a closer look at the literature on gluten-free bread making from 2010 up to the first part of 2015, thereby covering over 70% of all Web of Science papers on gluten-free bread making. The focus lies on the different analytical techniques used to determine the quality of gluten-free batter/dough and bread. The 399 articles included in Fig. 1 were narrowed down to only those describing original research on the West-European and North-American bread types. Such bread is typically sliced before use. 132 articles remained which are incorporated in the tables below. Each table groups the publications on a particular starch source, respectively rice flour, pure starches, ‘alternative flours’ and a combination of different flours and starches. Table 5 lists the research on sourdough bread making. Articles that focus only on nutritional aspects such as protein or starch digestibility and glycemic index (Cornejo et al., 2015; Wolter et al., 2013, 2014a) or antioxidant capacity (Sakac et al., 2011) were not included in the tables, as well as articles focusing only on the chemical composition (Costantini et al., 2014; de la Barca et al., 2010; Krupa-Kozak et al., 2011b; Wronkowska et al., 2010).

3.1. Gluten-free bread recipes

Each table lists the composition of the standard recipe, including flour or starch source(s) used and additives present both in control and tested sample. In recipes based on pure starches (Table 2), maize and potato starches are commonly combined. Some articles used only maize starch or a mix of maize and another starch. Rarely used starch sources were gluten-free wheat and rice. ‘Alternative flours’ (Table 3) include those from gluten-free cereal flours other than rice such as oat, corn, sorghum, millet and teff, from pseudocereals such as buckwheat, amaranth and quinoa, from tubers such as cassava and potato, from legumes such as soy and chickpea and from other raw materials such as chestnut, tigernut, and chia. In recipes with a combination of different flours and starches as basic ingredients (Table 4), rice flour was often combined with cassava, potato or corn starch. Wheat starch, sorghum flour and flour from pseudocereals such as amaranth, buckwheat and quinoa

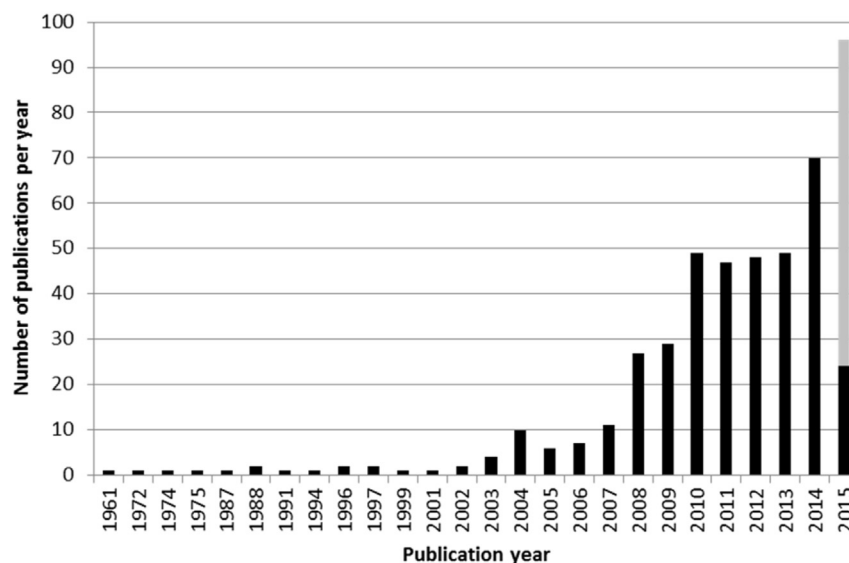


Fig. 1. Literature search on the topic gluten-free bread making. Source: Web of Science, all databases, leaving out research areas in the medical field, up until April 8th, 2015. The number of publications of 2015 (shown in grey) is estimated based on the number of publications during the first three months of that year.

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