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Review

Influence of hydrocolloids on dough handling and technological properties of gluten-free breads

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ABSTRACT

Background: The development of gluten-free breads has attracted great attention as a result of better diagnoses of relationship between gluten-free products and health. The market demand for gluten-free products is increasing day by day due to growing number of celiac disease cases. Development of gluten-free bread remains a technological challenge due to the key role of gluten in the breadmaking process and in bread structure, appearance, texture and shelf life.
Scope and approach: This review covers recent advances in the application of hydrocolloids in dough handling, technological and nutritional properties of gluten-free breads, which affect its quality and value.
Key findings and conclusions: Gluten-free breads results from the combination of different ingredients and hydrocolloids required to building up network structures responsible for bread quality. Various gluten-free formulations have applied hydrocolloids to mimic the viscoelastic properties of gluten. In addition, the impact of different hydrocolloids on the characteristics of dough and bread quality is known to be highly dependent on raw materials, the nature and quantity of hydrocolloids. Hydrocolloids improve the texture, increase the moisture content and extend the overall quality of bread. The results of the reviewed studies indicate that some of those products were acceptable and presented similar or better sensory attributes than control formulations and some were even comparable to their wheat-based counterparts. Based on successful applications of hydrocolloids, it is suggested that novel nutritious ingredients, combined with hydrocolloids can be added to gluten-free bread formulations to improve the quality of life.

1. Introduction

The demand of gluten-free products, especially bread is increasing as a result of the increase of celiac disease diagnosis (Cureton & Fasano, 2009). Market trends and the increasing diagnoses of celiac disease have encouraged extensive research for the development of gluten-free breads (Houben, Hochstotter, & Becker, 2012). Nevertheless, production of high quality gluten-free bread is a big challenge due to the absence of gluten, which confers unique viscoelastic properties to dough. Generally, bread development without gluten has involved the use of diverse ingredients and additives with the purpose of imitating the viscoelastic properties of the gluten and consequently to obtain quality bread products (Demirkesen et al., 2014; Hager & Arendt, 2013; Sciarini, Ribotta, Leon, & Perez, 2010).

To overcome this challenge, gluten-free bread formulations involving diverse approaches, such as the use of different gluten-free flours (rice, maize, sorghum) (Mancebo, Miguel, Martinez, & Gomez, 2015; Schober, Messerschmidt, Bean, Park, & Arendt, 2005; Sciarini et al., 2010), pseudocereals (quinoa, amaranth, buckwheat) (Hager & Arendt, 2013; Mariotti, Pagani, & Lucisano, 2013), legume flours (soya, chickpea, pea) (Aguilar, Albanell, Miñarro, & Capellas, 2015), starches (corn, potato, cassava) (Lazaridou, Duta, Papageorgiou, Belc, & Biliaderis, 2007; Mahmoud, Yousif, Gadallah, & Alawneh, 2013), and ingredients such as hydrocolloids, emulsifiers and shortenings or combinations thereof as alternatives to gluten, to improve their technological, sensory and nutritional properties, and also the shelf-life which leads to an

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increased final price (Demirkesen et al., 2014; Ronda, Perez-Quirce, Lazaridou, & Biliaderis, 2015).

Several additives are used to provide the dough properties and technology properties of bread (Capriles & Areas, 2014; Demirkesen, Sumnu, & Sahin, 2013). Among the additives, hydrocolloids are one of the commonly used to achieve this target (Houben et al., 2012; Matos & Rosell, 2015). Therefore, the applications of hydrocolloids or gums in gluten-free bread formulations are a promising alternative for the expansion of high-quality breads for a targeted consumer. Hydrocolloids consists a number of water soluble polysaccharides with varied chemical structures providing a wide range of functional properties that make them suitable for different applications in bread industry (Li & Nie, 2015). The hydrocolloids improve dough development and gas retention through an increase in viscosity, producing gluten-free breads with higher baking and quality properties (Capriles & Areas, 2014).

Investigations on gluten-free products, especially bread, have focussed on improving technological parameters including volume and crumb hardness in addition to sensorial perception (Houben et al., 2012; Kittisuban, Ritthiruangdej, & Suphantharika, 2014). Several hydrocolloids have shown the acceptable quality gluten-free breads (Table 1). In addition being applied as gluten substitutes in gluten-free breads, hydrocolloids have been used to improve texture, to increase the moisture retention, and to enhance the overall quality properties of the bread (Rojas, Rosell, & de Barber, 1999).

Table 1
Type of flour and hydrocolloids used in gluten-free breads.

Type of flour	Hydrocolloid	References
Rice	HPMC	Ronda et al. (2015)
Chickpea, tigernut, corn starch	Xanthan gum	Aguilar et al. (2015)
Rice	HPMC	Mancebo et al. (2015)
Rice, corn, corn starch	Cress seed gum, xanthan gum	Naji-Tabasi and Mohebbi (2015)
Brown rice	Xanthan, guar, locust, methycellulose, CMC, HPMC	Demirkesen et al. (2014)
Rice	HPMC	Kittisuban et al. (2014)
Rice, corn starch	CMC, Xanthan gum	Mohammadi et al. (2014)
Buckwheat	HPMC	Mariotti et al. (2013)
Rice, maize, buckwheat	HPMC, Xanthan gum	Hager et al. (2013)
Chestnut, chia	Guar gum, HPMC	Moreira et al. (2013a, b)
Rice, corn starch, potato starch	Xanthan gum, guar gum	Mahmoud et al. 2013
Chestnut, rice	Xanthan gum, guar gum	Demirkesen et al. (2013)
Rice, corn, soy	CMC, xanthan gum	Sciarini et al. (2012a)
Rice, corn, soy	Carrageenan, alginate, xanthan gum, CMC	Sciarini et al. (2010)
Cassava	Xanthan gum	Shittu et al. (2009)
Rice, potato starch	Xanthan gum, HPMC	Nunes, Moore, Ryan, and Arendt (2009)
Rice, corn starch	CMC, pectin, agarose, xanthan gum, β-glucan	Lazaridou et al. (2007)
Rice	HPMC	Lee and Lee (2006)
Rice, potato starch, corn starch	Xanthan gum	Moore, Heinbockel, Dockery, Ulmer, and Arendt (2006)
Rice	Xanthan gum, HPMC	Ahlborn et al. (2005)
Rice, potato starch	HPMC	McCarthy, Gallagher, Gormley, Schober, and Arendt (2005)
Sorghum	Xanthan gum	Schober et al. (2005)
Rice, potato starch	HPMC, CMC, guar gum	Cato et al. (2004)
Rice, corn starch, cassava starch	Xanthan gum	Lopez et al. (2004)
Rice	HPMC	Sivaramakrishnan et al. (2004)

CMC: carboxymethylcellulose; HPMC: hydroxypropylmethylcellulose.

There are numerous research papers and academic reviews which have focussed on the effect of additives on gluten-free bread. However, to the best of our knowledge, there is no such review focussing specifically on the influence of hydrocolloids on properties of gluten-free breads, which is a commonly used additive in the bread industry. Thus, the objective of this paper is to review the latest findings on the effect of hydrocolloids on gluten-free bread formulas, with particular emphasis on dough handling, technological and nutritional properties.

2. Why need gluten-free breads?

Celiac disease is one of the most common lifelong disorders on a worldwide basis. It is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals and is characterized by a strong immune response to certain amino acid sequences found in the prolamin fractions of wheat, barley and rye (Hill et al., 2005; Rosell, Barro, Sousa, & Mena, 2014). This disorder damages the villi, tiny hair like projections in the small intestine that absorb nutrients due to an immunological reaction to gluten resulting in damage to the mucosa and generalized malabsorption of nutrients (Cureton & Fasano, 2009).

At present, the only effective treatment for celiac disease is strict adherence to a gluten-free diet, through permanent withdrawal of gluten from daily food. In addition to patients with celiac disease, many individuals cannot tolerate gluten proteins due to Ig-E mediated allergic reactions and they too must avoid gluten containing foods (Matos & Rosell, 2015).

Bread is mostly consumed as major dietary source of calories (Ho, Tan, Aziz, & Bhat, 2015; Mir et al., 2014; Phimolsiripol, Mukprasirt, & Shoenlechner, 2012). Increasing numbers of diagnosed cases and growing awareness makes the availability of gluten-free breads an important socioeconomic and health issue. The production of high quality gluten-free bread made from ingredients other than wheat flour represents a major technological challenge. So it is necessary to develop the gluten-free breads with consumer acceptability.

3. Hydrocolloid functionality

Gluten is the main structure forming protein present in wheat, barley and rye. Gluten is responsible for the viscoelastic properties of dough which is compulsory to retain gas produced from yeast fermentation and oven rise during the production of bread (Houben et al., 2012). The replacement of gluten is a major challenge for food technologist to produce the breads with desirable quality and technological properties.

Hydrocolloids are one group of additives which fulfil this need. Hydrocolloids are used in gluten-free breads to improve dough handling properties and to enhance the quality and shelf-life of bread. They are capable of controlling the rheology and texture of aqueous systems throughout the stabilization of emulsions, foams and suspensions (Li & Nie, 2015). Hydrocolloids are water-soluble polysaccharides with diverse chemical structures depend on the type and provide a broad range of techno-functional properties, which make them extensively use in the food industry. They are used as structuring agents to mimic the viscoelastic properties of gluten. With the same aim of reinforcing dough structure, proteins have been added to gluten-free recipes, and cross-linking enzymes help to create a protein network.

The gluten-free bread quality is mainly influenced by the nature, content and properties of hydrocolloids, which increase dough foam stability by increasing viscosity, flocculation and coalescence, preventing effects on the dough aqueous phase and thus on the stability of the liquid film surrounding gas bubbles (Dickinson,