

Development of gluten-free cereal products

COELIAC DISEASE IS AN AUTO-IMMUNE DISORDER THAT CAN OCCUR IN PEOPLE OF ALL AGES. THE ONLY WAY TO TREAT THIS DISEASE IS WITH A GLUTEN-FREE DIET

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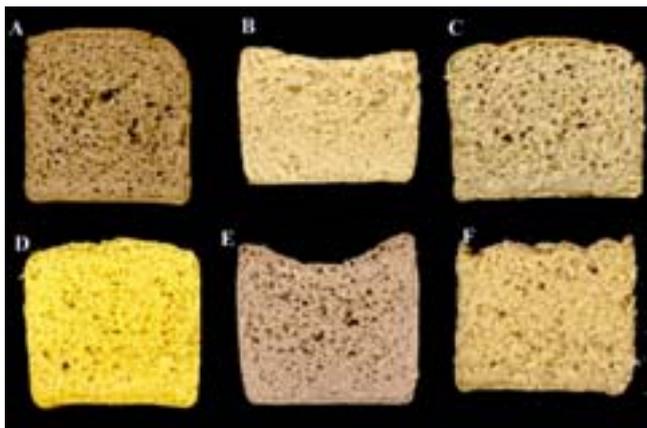
+ In genetically susceptible individuals, the ingestion of gluten and related proteins triggers an immune-mediated enteropathy known as Coeliac or Celiac Disease (CD). Recent epidemiological studies have shown that 1 in 100 people worldwide suffer from CD. Such a ratio establishes CD as one of the most common food intolerances. Coeliac patients eating wheat or related proteins such as hordeins (barley) or secalins (rye) undergo an immunological response, localized in the small intestine, which destroys mature absorptive epithelial cells on the surface of the small intestine. Currently, the only way that CD can be treated is the lifelong avoidance of gluten ingestion. Therefore, CD sufferers have to follow a very strict diet and avoid any products which contain wheat, rye or barley (some authors also include oats). The avoidance of these cereals leads to a recovery from the disease and significant improvement of the intestinal mucosa and its absorptive functions. Coeliac patients are not able to eat some of the most common foods such as bread, pizzas and biscuits or to drink beer. Due to the unique properties of gluten, it is a huge challenge for food scientists to produce high quality gluten-free products.



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The Irish Market for gluten-free cereal products

A wide range of gluten-free cereal products ranging from breads to pizza and biscuits were collected and subjected to



a range of physical and sensory tests. The former embraced texture profile analysis, moisture determination, crumb density, crust and crumb color. Particular attention focused on how quickly the products went stale. Sensory testing was also carried out by assessing the appearance (whole loaves and slices), crumbliness (in relation to the spreadability of butter), mouthfeel, overall texture and flavor. Overall it was found that the gluten-free products were of inferior quality and were very often of poor flavor. The structure of the products was predominately crumbly and very dry. The majority of bread products are sold as par-baked products which need to be reheated and are not suitable for sandwiches.

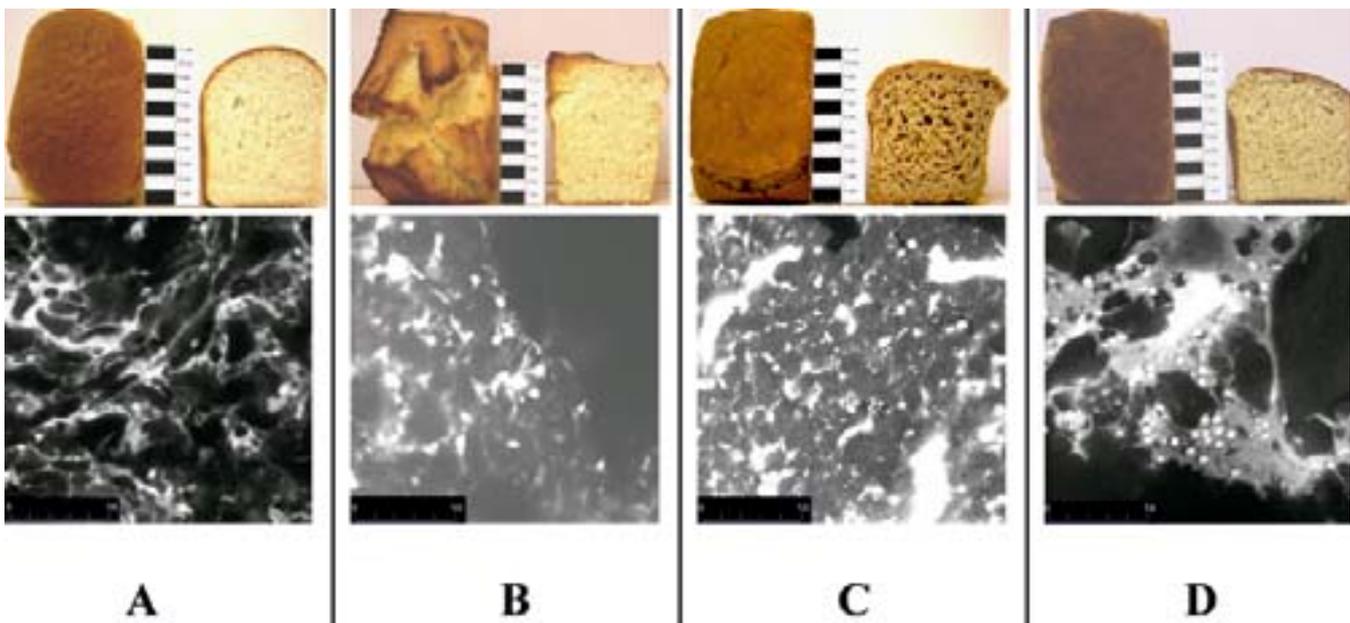
Gluten-free breads

Product formulation

The replacement of gluten in bread dough is one of the biggest challenges when working with gluten-free cereal products. This is reflected in the evaluation of products currently on the market which are mainly of inferior quality. The wheat protein, namely gluten, has such a wide variety of tasks in bread making, so that without it, a wide range of ingredients are needed to achieve a good quality product. The majority of the gluten-free flours as well as gluten-free products currently on the market are wheat starch based. However, they can still threaten the health of a coeliac patient, due to the very small amount of gluten that may still be present. The approach taken is to only work with flours and starches which are listed as gluten-free, such as, corn, potato, soy, buckwheat and rice. An overview of the production of bread from various gluten-free flours is shown in Figure 1. The starches were then combined with gums and dairy ingredients to produce gluten-free bread of a similar quality to that of wheat bread. The loaf volume, moisture, water activity and color of the baked goods were evaluated. The texture profiles and the extent of staling during storage of these

++ figure 1

Gluten-free breads produced from various gluten free flours and oats. A tef, B brown rice, C sorghum, D corn, E buckwheat, F oats.



++ figure 2

Wheat bread control (A) and gluten-free breads [bread from commercial gluten-free flour (B), optimised brown bread (C), optimised white bread (D)]. Outer appearance of the breads and microscopical structure as detected by confocal laser-scanning microscopy (magnification bar corresponds to 50µm)

baked goods were also determined. Sensory evaluation was also carried out with members of the Coeliac Association of Ireland as well as normal taste panels. Overall the products, which have so far been developed, are superior to any of the products on the market and are comparable to their wheat-based counterparts (Figure 2).

Improvement of gluten-free breads using enzymes

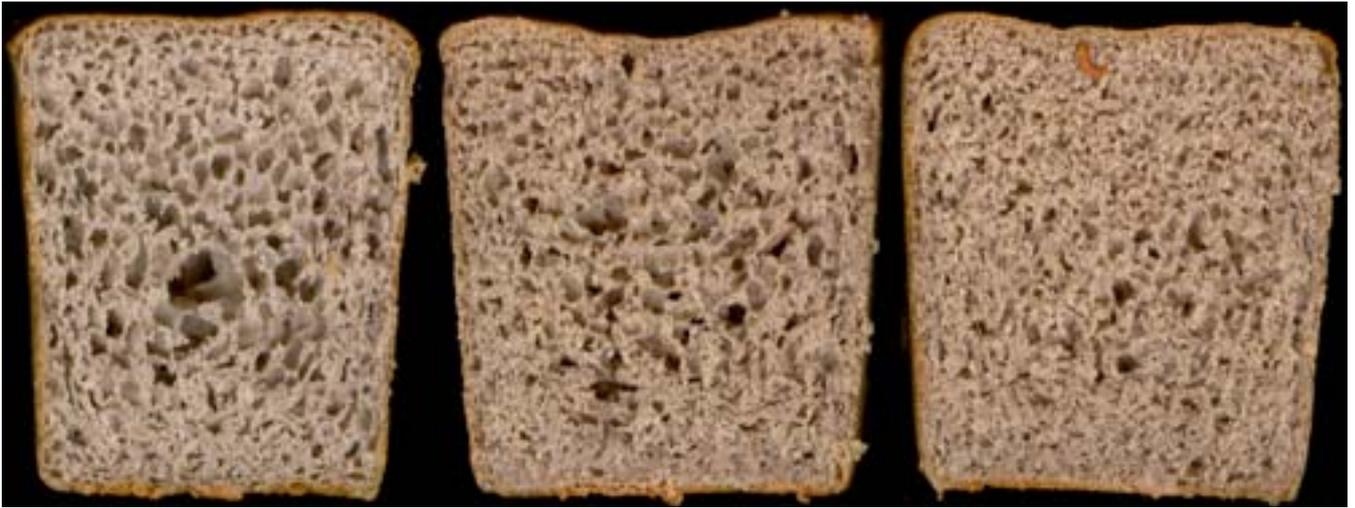
The use of enzymes is widespread throughout the baking industry, e.g. for de-colorization (bleaching) of dough, improvement of the volume and texture of dough and the increase of the shelf-life. Enzymes can either be naturally present in the raw materials or can be added from external sources. Amylases, proteases, hemicellulases, lipases and oxidases have been reported to influence all aspects of the baking process as well as the quality of baked goods.

Transglutaminase (TGase) is a relatively new tool used in the manufacture of baked goods. TGase can modify proteins by amine incorporation, cross-linking or de-amination. Cross-linking occurs when the ϵ -amino groups of lysine residues in proteins act as an acyl-receptor, ϵ -(γ -Glu)Lys bonds (isopeptide bonds) are formed both intra- and inter-molecularly. In the absence of primary amines in the reaction system, water is used as an acyl acceptor leading to a de-amination of glutamine residues. TGase can also catalyse the incorporation of primary amines into proteins. TGase has the ability to link proteins of different origins: casein and albumin from milk, animal protein from eggs and meat, soy protein and wheat protein. The enzyme can be obtained from a range of different sources, e.g. animal tissue, fish, plants or microorganisms. The TGases used in baking applications are obtained from microbial cultures. TGase is active against wheat gluten and has a positive effect on the specific volume of wheat-based croissants.

Recent work by the group evaluated the impact of TGase (at different levels) in gluten-free (GF) bread in conjunction with the protein sources soy, skim milk or egg powder. The most pronounced effect was the reduction in volume due to network formation. Bread containing skim milk powder and 10 units of the enzyme showed the most compact structure, which is seemingly due to the network formation in GF bread, which depends on the TGase level and the type of protein used. Also evaluated in depth was the impact of TGase on a range of GF cereals. A significant increase in the pseudoplastic behavior of buckwheat and brown rice batters was observed when 10 U of TGase was used. The resulting buckwheat and brown rice breads showed improved baking characteristics as well as an overall macroscopic appearance (Figure 3).

Sourdough and its role in improving gluten-free bread quality

The use of sourdough represents an attractive alternative for increasing the quality of gluten-free breads. Sourdough addition has a well-established role in improving the quality of gluten-containing bread. There is a considerable consensus of opinion with regard to the positive effects, including improvements in bread volume and crumb structure, flavor, nutritional value and mould-free shelf life. The improvement in flavor due to sourdough addition is of particular interest for GF bread production. The flavor of the bread can be influenced by the type of starter cultures used and characteristic flavors are obtained from organic acids and amino acids released during fermentation. Gas holding properties are mainly influenced by the swelling capacity of flour although starch granules are comparably water-insoluble and hardly hydrate in cold water. Acidification of flour by sourdough fermentation can replace the function of gluten in a way and enhance the swelling properties of poly- ▶



++ figure 3

Impact of different levels of Transglutaminase on bread produced from buckwheat flour (A) control; (B) 1 U/g Transglutaminase addition; (C) 10 U/g Transglutaminase

saccharides (pentosans in rye). This property may be beneficial to the structure of GF breads.

The influence of sourdough on the quality of GF bread was recently investigated by the group and it was found that, during fermentation, protein degradation occurred. However, this process was far less obvious than that occurring in gluten-containing sourdoughs. Incorporation of 20% sourdough has remarkable effects on the final quality of gluten-containing breads. However, when GF sourdough was incorporated at a 20% level into the GF batters, no significant differences were observed in the structure. Nonetheless, the onset of staling was delayed. Remarkably, it also showed that an addition of sourdough based on selected anti-fungal strains can effectively retard the growth of spoilage organisms on GF bread, therefore increasing the shelf life of these products.

Gluten-free biscuits

The three main ingredients of biscuits are wheat flour, fat and sugar. In different combinations, they form the basis of a full range of biscuit products. In gluten-free biscuits the wheat flour, which originates from soft winter wheat, needs to be replaced by other ingredients. These ingredients need to replace not only the starch, which is delivered by the wheat flour, but also the protein fractions. The advantage in developing gluten-free biscuits is that the formation of a gluten network is unwanted in a lot of biscuit products. The objective of the research was to develop a biscuit, which is as close as possible to wheat based products. A variety of starches ranging from corn, soy, millet, rice and potatoes was combined with different types of fat (palm oil, cream powder, microencapsulated high fat powder and low fat dairy powder). The dough characteristics as well as the texture, color and moisture, dimensions and sensory attributes were evaluated. It was found that combinations of rice, potato, corn and soy with high fat powders produced biscuits of comparable quality to the ordinary biscuits.

Gluten-free pizza

Pizza has become one of the most popular convenience products. Currently, the quality of gluten-free products is poor and is closer to a cake product than a wheat dough pizza. Tests which covered dough stickiness and hardness, volume, color and pizza texture confirmed that it is possible to produce a gluten-free pizza product with similar attributes to the wheat based variety.

Conclusion

The keystone treatment of CD patients is a lifelong elimination diet in which food products containing gluten are avoided. However, gluten is an essential structure-building protein, contributing to the appearance, crumb structure, and consumer acceptability of many baked products. Flours and starches from naturally gluten-free sources constitute the basis for gluten-free bread formulations. Even so, it is difficult to assess the impact of each flour and/or starch on the microstructure and textural characteristics of batters and breads. In fact, such ingredients are only part of a more complex formulation involving several functional ingredients, and thus interactions can play a major role. Dairy ingredients, gums and hydrocolloids are traditionally included in GF formulations to meet the unique nutritional needs and sensory requirements of CD patients. New approaches such as the use of enzymes or addition of sourdough currently constitute promising alternatives. Nonetheless, a market evaluation clearly demonstrates that there is still a major challenge to improve the structure, mouthfeel, consumer acceptability and shelf-life of GF products.

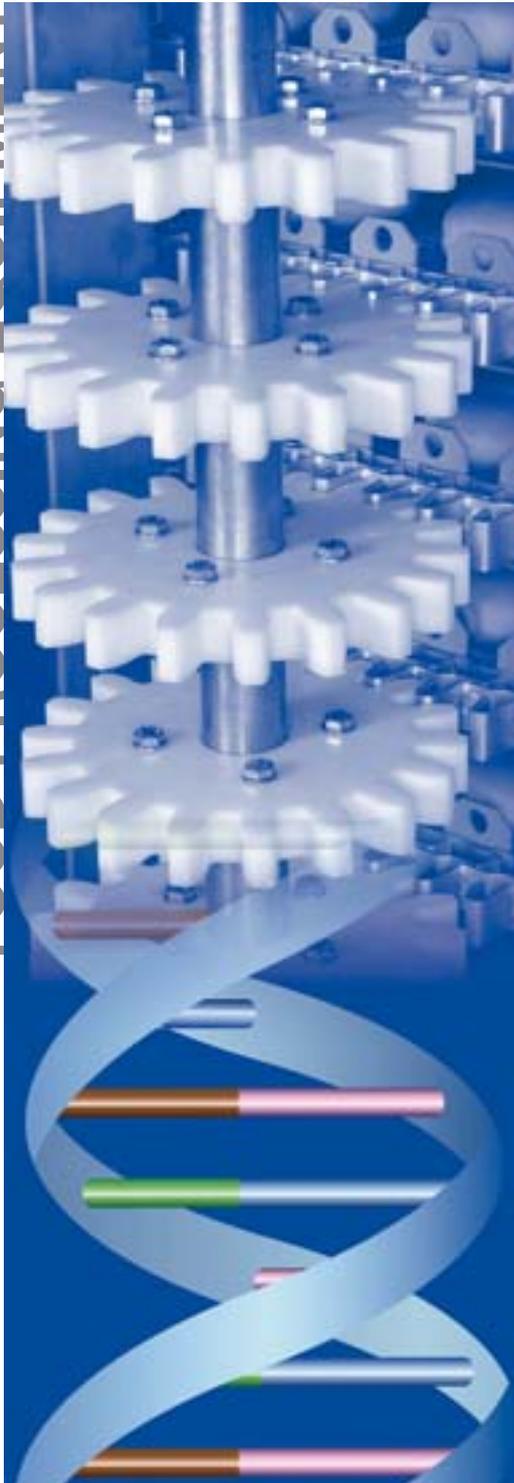
Recommended reading material

Arendt EK and Dal Bello F (eds) (2008). *Gluten-free Food and Beverages*. Academic Press – Elsevier. ISBN978-0-12-373739-7. +++

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