Gluten-free bread research

Pseudocereals are being investigated as possible functional ingredients in gluten-free breads by researchers at Teagasc Food Research Ashtown.

Greater public awareness and improved diagnostic procedures have combined to highlight the prevalence of coeliac disease (CD) and gluten intolerance in the general population. The estimated mean prevalence of CD is 1% of the general population. The only accepted treatment for CD is a strict, life-long elimination of gluten from the diet. Many widely consumed staples, such as bread and pasta, are made using gluten-containing grains such as wheat, which must be avoided by coeliac patients. Although gluten-free alternatives are readily available in the market, these products are often characterised by a crumbly, brittle texture, and are perceived as being of inferior quality compared to the wheat products they are intended to replace. In addition to quality defects, gluten-free foods are also characterised by an inferior nutritional quality. They have been reported to contain lower levels of essential nutrients such as B vitamins, iron and fibre, than are contained in wheat products. This is mainly due to the fact that gluten-free products are generally formulated with starches and refined flours, and are not usually fortified.

Research at Teagasc Food Research Ashtown (TFRA) has addressed some of the nutritional needs of coeliacs by formulating palatable, gluten-free breads with enhanced nutritional properties. It has focused on using the so-called 'pseudocereals' amaranth, quinoa and buckwheat to replace wheat in bread formulations. In botanical terms, these are not true cereals; they are dicotyledonous plants as opposed to most cereals (e.g., wheat, rice, barley), which are monocotyledonous. They are referred to as pseudocereals as their seeds resemble those of the true cereals in function and composition. They are, however, gluten-free, and are also rich in nutrients; therefore, their incorporation in the gluten-free diet could not only add variety but also improve nutritional quality. Other characteristics of these seeds, such as their high protein, fibre and mineral content, as well as the presence of many bioactive components (compounds with beneficial effects on the body), make them attractive alternatives to traditional gluten-free ingredients (such as rice, potato and corn flours/starches) in the production of high quality, healthy gluten-free products.

Research approach

A gluten-free bread recipe similar to commercially used formulations and based on rice flour and potato starch was used as a control. One of the pseudocereals (amaranth, quinoa or buckwheat) replaced the potato starch in each of the experimental formulations.

Improved baking characteristics of breads with pseudocereals

Initially, the baking characteristics of the resulting breads were assessed. Dough rheology, specific loaf volume, textural properties, crumb grain/imaging and sensory analysis were completed. Some of the results are shown in **Figure 1**. Loaf volumes were significantly increased for buckwheat and quinoa breads in comparison with the control. Loaf volume is an important determinant of bread quality. A good loaf volume, coupled with a good crumb texture, indicates proper dough formation and a high quality product. No significant difference in volume was found between the control breads and those containing amaranth. In relation to the crust colour of the baked breads, the pseudocereal-containing gluten-free breads were significantly darker (lower L* values) compared to the gluten-free control. The darkening of crust colour brought about by the replacement of potato starch by a pseudocereal flour is desirable, as gluten-free breads tend to have a lighter crust colour than white wheat breads and can sometimes appear artificial.

In breadmaking, a desirable crumb structure is characterised by a large number of small, thin-walled cells and a soft, spongy texture. In the present study, the largest number of cells was found in breads containing buckwheat and quinoa (**Figure 2**). All pseudocereal-containing gluten-free breads had a softer, more desirable crumb than the gluten-free control. A similar trend was found for crumb cohesiveness, with all of the pseudocereal-containing breads producing a more cohesive crumb than the control product. In sensory studies, the differences observed in the acceptability of the baked breads were not statistically significant, showing that pseudocereal flours may be introduced into a gluten-free bread formulation to

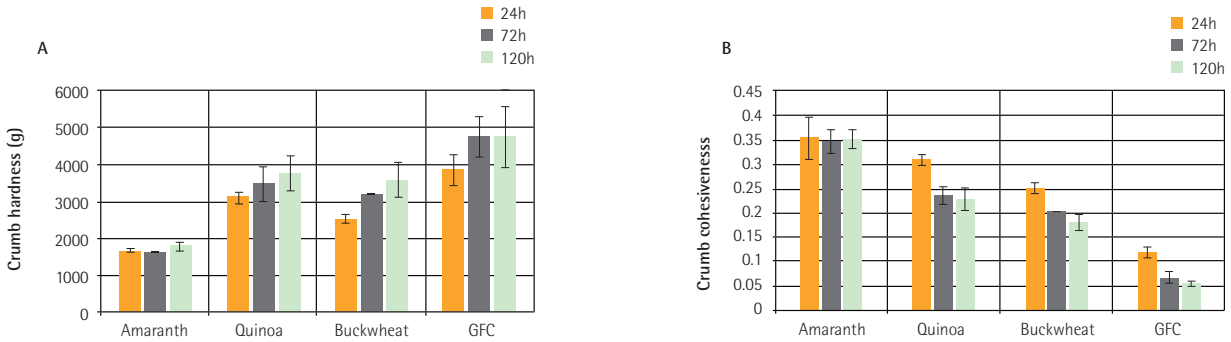

FIGURE 1: Texture profile analysis of the breads 24, 72 and 120 hours post baking: (A) crumb hardness: a softer crumb is more desirable; (B) crumb cohesiveness: a more cohesive crumb is more desirable; GFC = gluten-free control.

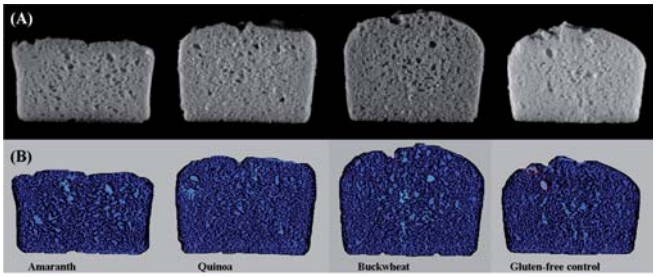

FIGURE 2:
Above: Raw (A) and cell (B) images of amaranth, quinoa, buckwheat and gluten-free control breads. Right: The bread loaves: 1 = gluten-free control, 2 = quinoa, 3 = amaranth, 4 = buckwheat.

enhance crumb softness and cohesiveness without adversely affecting the sensory properties of the loaves. Confocal microscopy of the bread crumb revealed a more homogenous structure in the pseudocereal-containing gluten-free breads, with a more even distribution of fat, protein and starch.

Enhanced nutritive properties

The inclusion of pseudocereal flours produced breads that were characterised by a significantly higher content of protein, fibre, antioxidant capacity and total phenols (**Table 1**). The protein content in these breads was, in all cases, at least twice the value of the control bread. Dietary fibre content also increased significantly. In particular, the fibre content of buckwheat bread, at 23.3%, was more than three times that of the gluten-free control (wheat bread has a fibre content of approximately 4%).

Antioxidants prevent food oxidation during cooking and storage, and can also protect the body from degenerative diseases such as cancer and heart disease. It was found that the antioxidant capacity, measured by both DPPH and FRAP assays, was increased by the presence of the pseudocereals in the breads, compared with the gluten-free control, with the buckwheat bread having the highest overall result.

General conclusions

This project evaluated the nutritive properties of the pseudocereals amaranth, quinoa and buckwheat, and their application as functional ingredients in a gluten-free formulation. All pseudocereal-containing gluten-free breads had a significantly softer crumb in comparison with the gluten-free control. Nutritional studies revealed that gluten-free breads containing pseudocereals had significantly higher levels of protein and dietary fibre in comparison with the gluten-free control. The nutritional value of these breads was also in line with the existing nutritional recommendations for CD diets and CD products. Also, all of the pseudocereal breads showed significantly higher antioxidant activity and polyphenol content compared with the gluten-free control.

Further developments

In an ongoing collaborative project between Ashtown and Moorepark, researchers are investigating the conditions required to produce a dairy-based ingredient with properties similar to gluten in a gluten-free dough system. So far, the researchers have found that under optimum conditions of pH and calcium concentration, casein aggregates and forms a protein network capable of retaining gas in gluten-free dough, similar to wheat dough. This work is still in progress.

Table 1: Chemical composition, antioxidant capacity and phenol content of the gluten-free and wheat breads.

Bread type	[1]Protein	[1]Dietary fibre	[2]Antioxidant capacity
GF control	4.18 ± 0.0	7.6 ± 0.9	47.59
Amaranth	11.6 ± 0.0	17.2 ± 0.8	60.6
Quinoa	10.1 ± 0.1	16.1 ± 0.6	71.42
Buckwheat	8.4 ± 0.4	23.3 ± 0.7	147.66
Wheat bread	11.9 ± 0.1	13.4 ± 0.8	81.67

[1] (% dry-weight basis) [2] (mg Trolox/100g DW)

Benefits to industry

The ingredients, formulations and technologies that have been studied and developed in these projects have yielded novel information, which will help to provide the industry with healthy, viable alternatives to the more traditional approaches in gluten-free formulation and baking.

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