# Manufacture of gluten-free breads – a question of the substrate?

THE TECHNISCHE UNIVERSITÄT MÜNCHEN (TECHNICAL UNIVERSITY OF MUNICH) HAS OPTIMIZED BUCKWHEAT FRACTIONATION TO IMPROVE GLUTEN-FREE BAKED GOODS BY USING THESE MILLING FRACTIONS

| ++ table 1 | buckwheat | | |
|---|---|---|---|
| | *ultra centrifuge mill* | *roller mill MLU 202* | |
| **fraction** | whole grain flour | bran | flour |
| yield (%) | 100.0 | 39.5 | 60.5 |
| **analytical composition** | | | |
| ash(% db) | 1.93 ± 0.04 | 5.27 ± 0.04 | 0.57 ± 0.03 |
| protein(% db) | 13.38 ± 0.25 | 43.78 ± 0.29 | 4.63 ± 0.26 |
| fat(% db) | 2.21 ± 0.08 | 6.95 ± 0.03 | 0.78 ± 0.04 |
| starch(% db) | 69.75 ± 1.71 | 29.17 ± 0.87 | 87.15 ± 0.46 |
| **functional characteristics** | | | |
| solvent retention capacity (%) | 96.73 ± 6.80 | 173.51 ± 12.56 | 87.43 ± 4.19 |
| pasting temperature (°C) | 72.3 | | 70.9 |

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++ table 1
Analytical composition and functional properties of buckwheat milling fractions compared to whole grain flour. Mean values (n = 2) are shown together with standard deviations abbreviation: db = dry base

Consumer-specific baked goods are becoming increasingly important in the context of a healthy, low-allergen diet. The growing prevalence of coeliac disease in Europe is between 0.4 and 0.7 % with a rising trend [Catassi & Fasano, 2005], and represents only one aspect of the importance of developing high-quality gluten-free baked products. Due to the lack of a gluten network, the corresponding baked goods often have reduced volume and a dry, brittle crumb [Gallagher & Gormley, 2002]. Furthermore, the raw materials most often used, such as rice flour or corn starch, contribute a low nutritional value. Due to their composition, pseudocereals provide an excellent alternative to counteract these quality deficits. Compared to conventional cereals, buckwheat is gluten-free and is also one of the plants with the highest protein content. Moreover, it has a high flavonoid and polyphenol content, which is not the only reason why it is a very promising substrate from the nutritional-physiological point of view for the manufacture of gluten-free baked goods. The health benefits include the potential to prevent Type 2 diabetes and a reduction in the level of cholesterol [He et al., 1995]. The buckwheat species normally used is called *Fagopyrum esculentum*, the majority of which is cultivated in Eastern Europe and Asia, and bears pyramid-shaped seeds. Although pseudocereals are mostly used in the form of whole grain flour, fractionation has been used in the case of wheat for a long time to utilize technological and functional advantages.


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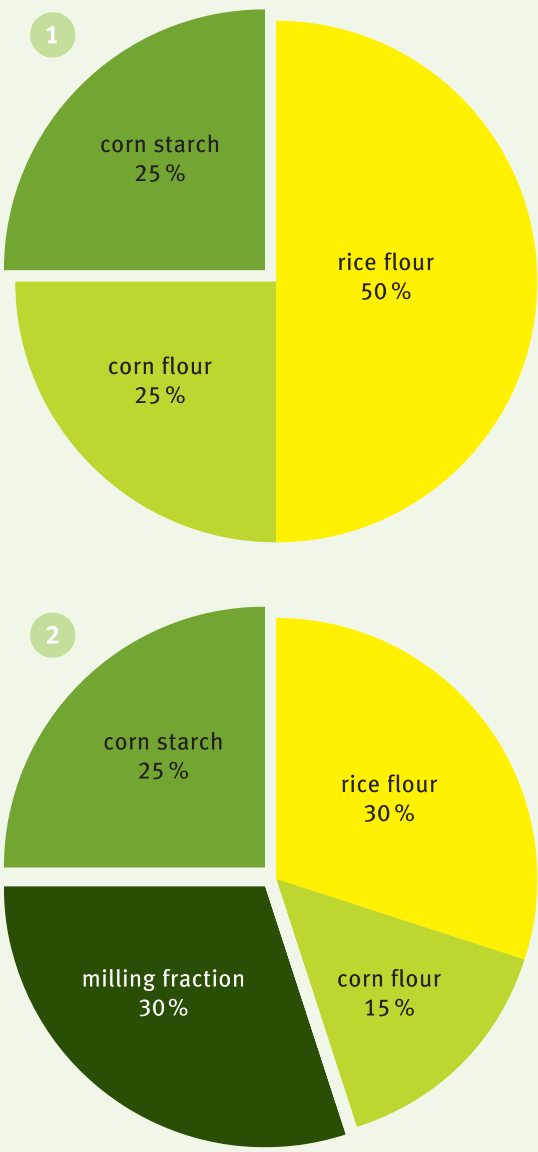
This novel approach was chosen to improve the quality characteristics of gluten-free baked goods in the context of AiF Project 16847 N at the Technische Universität München, Institute of Brewing and Beverage Technology, Research Group Cereal Process Engineering. The first step in this direction was to optimize in particular the fractionation of quinoa and buckwheat. Furthermore, in cooperation with the German Institute of Food Technologies (DIL, Quakenbrück), the main aim was to study and optimize the dough rheological and baking technological potential of the milling fractions against the background of substrate availability, varying endogenous enzyme activity and the growth of lactobacilli.

**Buckwheat milling fractions and experimental setup**

The use of an MLU 202 laboratory mill to fractionate buckwheat grains was established as a successful separation method. It yielded eight different fractions which, after determining the milling yields and ash content, were combined into one flour fraction and one bran fraction. Compared to whole grain flour, produced by using an ultracentrifuge mill, this optimized process separated the outer layers (seed coat) from the endosperm. Thus the starch was greatly enriched to over 80 % in the flour fraction, and the protein content in particular to more than 40 % in the bran fraction (see table 1). Consequently, the water absorption in the flour fraction (determined using AACC Method 56-11) was significantly reduced due to the decreased protein and dietary fiber content, which was reflected in a lower gelatinization temperature compared to whole grain, as determined by using a Rapid Visco-Analyzer. ▶

++ figure 1

**Recipe**

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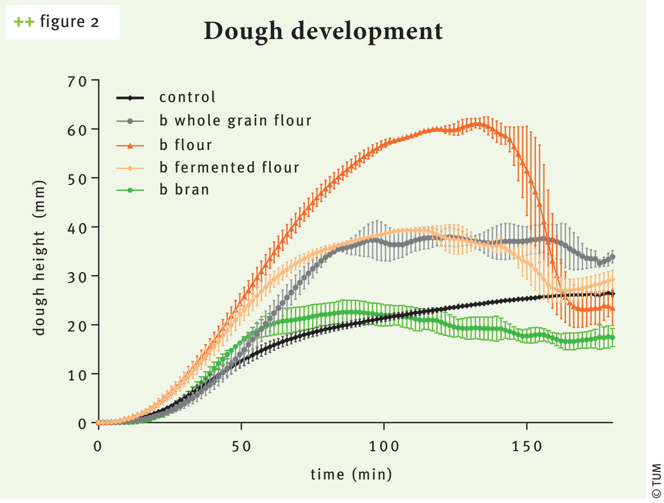
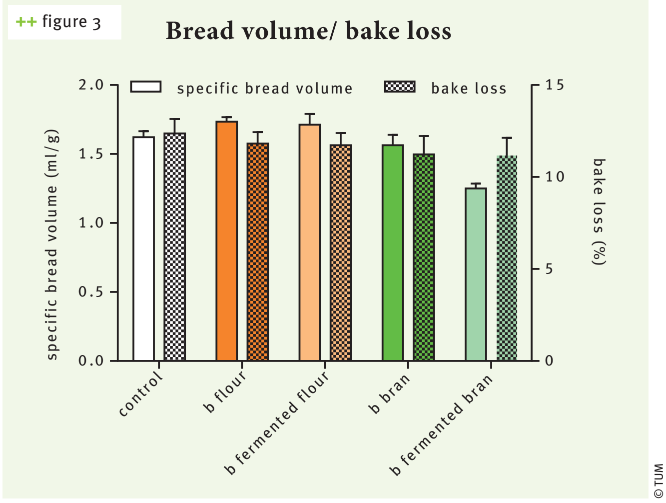
**++ figure 1**
Illustration of the proportions of gluten-free flours in the control recipe (1) and after replacement of rice-corn flour mixture by 40 % of buckwheat milling fractions (2)




**++ figure 2**
Development of dough height after replacing rice and corn flour by 40 % of a buckwheat milling fraction. Mean values (n = 2) are shown together with standard deviations




**++ figure 3**
Specific bread volume and baking loss of gluten-free breads after replacement of rice and corn flour by 40 % of buckwheat milling fractions. Mean values (n = 24) are shown together with standard deviations

The control flour mixture for gluten-free dough and bread preparation consisted of rice, corn flour and corn starch, in the proportion 2:1:1. For further baking trials rice and corn flour were replaced (2:1) by quinoa bran (40–100 %), while the amount of corn starch remained constant (see figure 1). The following results for buckwheat are presented as a comparison for a 40 % replacement. To 100 g of flour mixture, further ingredients were added: distilled water (80 g), margarine (3 g), HPMC (2 g), NaCl (2 g) and dry yeast (1.5 g).

On each occasion the ingredients were mixed and kneaded for 2 min in a laboratory spiral kneader (DIOSNA Dierks & Söhne GmbH). The dough temperature was adjusted to 28 °C by adding water at a controlled temperature. A dough resting time of 15 min and loading into the baking pans (250 ± 0.5 g) was followed by a proofing time of 45 min at 30 °C and 80 % relative air humidity in a proofer made by Koma Koeltechnische Industrie B.V. Baking took place in a multi-deck oven (WP BAKERYGROUP) at 220 °C for 35 min with an initial input of steam. The buckwheat milling fractions were fermented using the *Lactobacillus plantarum* strain. In addition to *L. paralimentarius*, this is one of the lactobacilli most frequently used with spontaneously fermented gluten-free cereals [Moroni et al., 2009]. The following procedure was used to manufacture sourdoughs at the DIL: the buckwheat milling fractions were prepared at a dough yield of 200 using *L. plantarum* at the rate of $10^7$ cfu (colony-forming units) per gram of dough and were fermented at 30 °C for 24 h before being added to the dough.

**Effect on the quality properties in gluten-free doughs and breads**

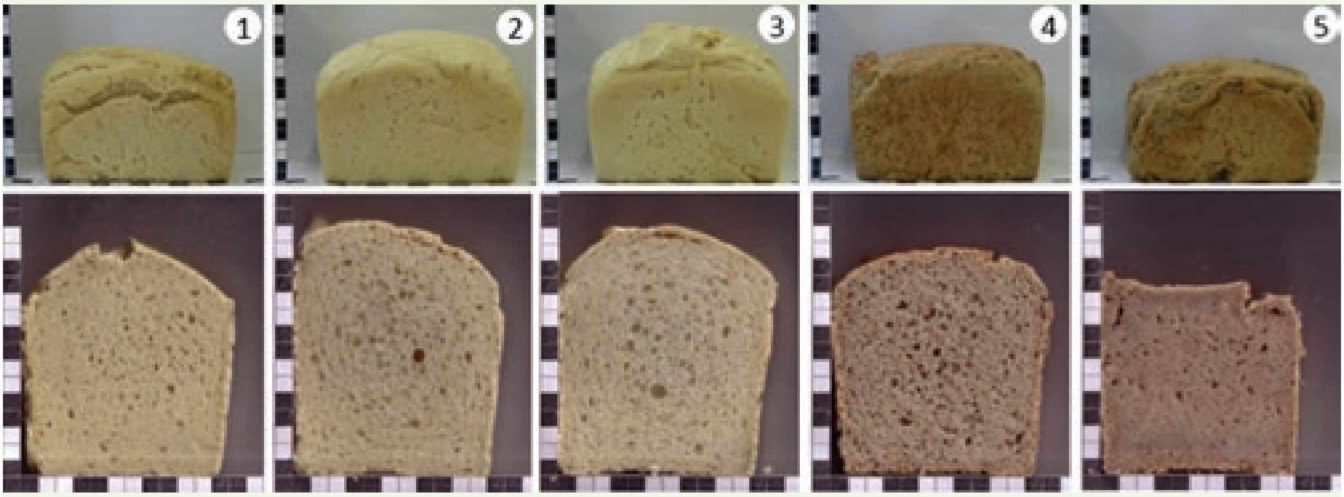
The development of the gluten-free doughs during the proofing phase was recorded for 180 min using a rheofermentometer. During this time the formation of $CO_2$ by the added yeast causes the volume of the dough to increase, and is thus partly responsible for the final volume and crumb porosity of the breads. Compared to whole grain flour, buckwheat flour promoted dough development, and no significant differences were detectable as a result of using buckwheat sourdough (see figure 2). The increase in dough height due to the flour fractions compared to whole grain flour was attributed to a higher endogenous α-amylase activity in buckwheat flour. This increased the formation of monosaccharides and consequently increased the availability of substrate for yeast. In contrast to this, buckwheat bran significantly reduced the dough height. Therefore, in addition to the structure weakening effect of bran particles, it could be suspected that the yeast metabolism is inhibited by tannins present locally in the outer layers of the seed.

The bread volume is closely correlated with crumb porosity, and represents an important quality characteristic in gluten-free bread. The bread volume was analyzed using a laser-assisted volumeter made by Perten Instruments, followed by calculation of the specific bread volume and baking loss (see figure 3).

The use of buckwheat flour increased the specific bread volume by 7 % compared to the control. Whereas the use of buckwheat flour did not change the browning intensity, the crumb revealed distinctly coarser pores compared to the control (see figure 4). The absence of browning was attributed to the low glucose concentration (0.14 g per 100 g of dough) together with a lower proteolytic activity (0.33 U) in buckwheat flour compared to bran (1.86 U) and the associated absence of the Maillard reaction. One U corresponds to the amount of enzyme required to liberate one µmole of free amino groups per hour and g of dough, measured using high pressure liquid chromatography. The use of fermented buckwheat flour did not significantly affect the specific bread volume. Although glucose and fructose were re-formed by the flour's endogenous enzymes during the incubation time, the crust color did not change after the use of fermented buckwheat flour. According to the studies at the DIL, this could be an indication to hydrolysis of sucrose or even enzyme activities

++ figure 4

**Gluten-free bread/ crumb structure**




1: control recipe based on rice and corn flour and corn starch; 2: 40 % B flour; 3: 40 % fermented B flour; 4: 40 % B bran; 5: 40 % fermented B bran. 1 box corresponds to 0.5 cm. B = buckwheat



**++ figure 4**
Appearance of the gluten-free breads and crumb porosity after replacement of the rice-corn flour mixture by 40 % buckwheat flour and bran

followed by the metabolisation of glucose through the lactobacillic strains. The replacement of the control flour mixture by buckwheat bran reduced the bread volume by 3.6 %, and by 18.1 % after fermentation, with a distinctly darker crust color and a more compact crumb structure. The intensity of browning was attributed to the color-producing pigments contained in buckwheat bran and to the considerably higher sucrose concentration of 3.38 g per 100 g of dough. The water evaporated during crust formation led to a baking loss of between 11–12.5 % in the gluten-free breads. In particular, the application of fermented buckwheat bran reduced the baking loss compared to the control. This was attributed to the fact that the bran binds comparatively more water and consequently releases less during the baking process.

**Summary and conclusions**

The results show that fractionation represents a successful separation process to enrich the functional grain components from buckwheat. Furthermore, the choice of the respective milling fraction (flour; bran) decisively determines the quality of the end product. A concentration smaller than the reference concentration of 40 % fermented buckwheat bran, selected in this paper, would need to be chosen in actual practice. Thus for example the literature describes the use of up to 20 % of fermented bran, depending on the applied substrate, with positive effects on the bread quality characteristics. The specific bread volume, porosity, pore size and crumb texture can be improved by using buckwheat flour. Furthermore, buckwheat bran not only yields a high quality milling product from the nutritional point of view, but can also be used to achieve a specified adjustment of the protein content or crust browning. Thus the application of milling fractions represents an additional tool for industrial use to adjust the end product quality of gluten-free baked goods to match consumer wishes.

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