facts

Xanthan Gum
in gluten-free bread

Jungbunzlauer
From nature
to ingredients®

Introduction

Until recently, the sole purpose of a gluten-free claim has been to indicate the suitability of food products for people suffering from coeliac disease. Coeliac disease is one of the most common diseases resulting from environmental (gluten) and genetic factors, affecting approximately 0.5–1% of people around the world. It is a lifelong autoimmune disease of the small intestine, caused by a reaction to gluten. Classic symptoms include gastrointestinal problems such as diarrhoea, steatorrhoea and weight loss due to malabsorption (Gujral et al., 2012).[1]

Nowadays, gluten-free claims are no longer just attracting the attention of people suffering from coeliac disease. “Healthy” and “free from” are two of the watchwords for baked goods. Of all the “free from” claims, gluten-free is particularly relevant (Euromonitor International, 2016).[2] While improved diagnosis facilitates confirmation of coeliac disease and results in an increased range of gluten-free products, a growing number of health-conscious people believe gluten to be fundamentally unhealthy and they, too, avoid it. Thus the tremendous rise in gluten-free products in recent years stems from the general popularity of “free from” and allergen-free products. The market has also grown as a result of “free from” consumers widening their repertoire, with almost half of those who eat or buy “free from” products saying they are likely to eat more from this range over the coming year. Although the “free from” market is thought to be slowing down, individual eating patterns will become the norm, offering technological hurdles to producers who have to deal with the challenge in order to cater to this trend (Mintel, 2014).[3]

The challenge of developing gluten-free breads

Conventional bread baking commonly uses flours like wheat, rye, triticale, and barley, which contain two different types of naturally-occurring protein fractions: glutenin and gliadin. Glutenin is responsible for the elasticity of dough, while gliadin contributes to its viscosity. Hydration of these proteins commences when water is added. The two proteins begin to stick to each other through the formation of chemical bonds. This causes the development of a strong yet very elastic protein complex known as a gluten network. This gluten network contributes to the supporting structure of the loaf and retains the carbon dioxide in the dough. The high elasticity of the gluten network and the ability to trap the gas enables the dough to rise and expand.

Unfortunately, gluten-free flours such as corn or rice flour are not able to provide the same elastic matrix needed for the typical structure and textures associated with bread. Therefore, if the gluten network is missing, additional ingredients are needed to mimic the function of gluten.

Gluten-free breads baked without the addition of such ingredients tend to be very dense with a crumbly structure. Moreover, the taste and the overall quality are often perceived as inferior, and gluten-free breads tend to go stale very quickly (Demirkesen et al., 2013).[4]

Jungbunzlauer offers xanthan gum as a solution to these problems. Xanthan gum can be used as the sole hydrocolloid in gluten-free recipes, but also shows outstanding performance in combination with other hydrocolloids.

Xanthan Gum – a fermentation-based hydrocolloid in gluten-free bread

Xanthan gum is a polysaccharide with extraordinary rheological behaviour. It dissolves readily in cold and hot water and forms viscous, pseudoplastic solutions. Even at low concentrations, xanthan gum solutions show a high degree of viscosity unaffected by temperature and pH variations. All of these properties make xanthan gum a very effective stabilizer and thickener. It imparts a pleasant consistency to the final product, improves sensory properties and provides long-term stability.

Many studies have demonstrated that hydrocolloids such as xanthan gum are suitable for replacing the gluten network, due to their diverse functional properties (Lazaridou et al., 2007).[5] They generally enhance the volume, texture and final quality of gluten-free bread (Mir et al., 2016).[6]

Two of the most popular hydrocolloids currently used for gluten replacement are xanthan gum and HPMC (Hager; Arendt, 2013).[7]

Description of lab test set-up

Experiments were performed on three sets of recipes: the first set (recipe 1) focused on the effect of xanthan gum as the sole hydrocolloid, the second set (recipe 2) compared different xanthan gum types from Jungbunzlauer and a xanthan gum from a competitor, and the third set (recipe 3) looked into hydroxypropyl methylcellulose (HPMC) alone and combinations with xanthan gum. The breads in recipes 1 and 3 were compared to each other in terms of bread ageing/staling and visual appearance. Furthermore, recipe 1 was evaluated for its sensory properties. The breads from recipe 2 were evaluated for loaf deformation, i.e. height and width.

Recipe 1

In the first recipe xanthan gum was used as the sole stabiliser. The purpose of this test was to investigate whether the addition of xanthan gum can improve the texture and sensory parameters of gluten-free bread. Four different quantities of xanthan gum were tested, using the same recipe.

Recipe ingredients

R1 NXG (recipe 1 with no xanthan gum): 34.8% flour mix; 4.8% starch mix; 5% egg white (solid); 3.4% sugar; 0.9% salt; 0.9% yeast; **0% xanthan gum**; 50.2% liquids

R1 1% XG (recipe 1 with 1% xanthan gum): 33.8% flour mix; 4.8% starch mix; 5% egg white (solid); 3.4% sugar; 0.9% salt; 0.9% yeast; **1.0% xanthan gum**; 50.2% liquids

R1 1.5% XG (recipe 1 with 1.5% xanthan gum): 33.3% flour mix; 4.8% starch mix; 5% egg white (solid); 3.4% sugar; 0.9% salt; 0.9% yeast; **1.5% xanthan gum**; 50.2% liquids

R1 2% XG (recipe 1 with 2% xanthan gum): 32.8% flour mix; 4.8% starch mix; 5% egg white (solid); 3.4% sugar; 0.9% salt; 0.9% yeast; **2.0% xanthan gum**; 50.2% liquids

Description of bread preparation

Blend all dry ingredients (except yeast) and mix until uniform. Add water to a kneading bowl and dissolve yeast. Add oil to the water and yeast mixture. Add dry blend to the liquids. Knead into dough with kneader for 1 min. at low speed (100 rpm) and 4 min. at high speed (500 rpm). Put 600 mL dough in a greased baking tin (21.6 x 11.5 x 7.1 cm) and proof for 65 min. at 34°C and 90% relative humidity.

Baking regime

5 min. at 220°C (insert 2*400 mL steam at start and end of 5 min. baking) and 40 min. at 200°C.

Recipe 2

In this second set different xanthan gum types from Jungbunzlauer and one competitor xanthan gum were used to prepare the gluten-free bread. The quantity of xanthan gum added stayed constant at 1.2%.

Recipe ingredients

36% flour mix; 5.4% starch mix; 7.4% whole egg (solid); 4.1% milk powder; 2% sugar; 1% salt; 0.6% yeast; **1.2% xanthan gum**; 42.3% liquids

Seven different Jungbunzlauer xanthan gum types were tested and are afterwards referred to as R2 JBL 1, 2, 3, 4, 5, 6, and 7. The recipe containing the competitor's xanthan gum will be referred to as R2 COMP.

Description of bread preparation

Blend all dry ingredients and mix until uniform. Combine liquids and pour into dry mixture. Knead dough with kneader for 1 min. at low speed (95 rpm) and 6 min. at medium speed (180 rpm). Put 1200 g dough in a greased baking tin (33 x 10 x 10 cm), spray water on top of loaf, cover it, and proof for 60 min. at 22°C and 50–60% relative humidity.

Baking regime

90 min. at 175°C.

Recipe 3

The purpose of this test was to compare a gluten-free bread recipe stabilised by HPMC alone with the same recipe where HPMC and xanthan gum were combined in different ratios.

Recipe ingredients

The following full HPMC recipe was prepared as the reference recipe:
R3 NXG (recipe 3 with no xanthan gum): 38% flour; 5.2% starch mix; 3.4% sugar; 0.9% salt; 0.9% yeast; **1% HPMC**; 50.6% liquids

Using this recipe as a basis, the HPMC quantity was decreased in steps, while the quantity of xanthan gum was increased. Three different ratios of HPMC to xanthan gum were tested:

R3 0.2% XG (recipe 3 with 0.2% xanthan gum): 38% flour; 5.2% starch mix; 3.4% sugar; 0.9% salt; 0.9% yeast; **0.8% HPMC; 0.2% xanthan gum**; 50.6% liquids

R3 0.3% XG (recipe 3 with 0.3% xanthan gum): 38% flour; 5.2% starch mix; 3.4% sugar; 0.9% salt; 0.9% yeast; **0.7% HPMC; 0.3% xanthan gum**; 50.6% liquids

R3 0.4% XG (recipe 3 with 0.4% xanthan gum): 38% flour; 5.2% starch mix; 3.4% sugar; 0.9% salt; 0.9% yeast; **0.6% HPMC; 0.4% xanthan gum**; 50.6% liquids

Description of bread preparation

Blend all dry ingredients and mix until uniform. Combine water and oil in a kneading bowl and add dry mixture. Knead into dough with kneader for 2 min. at low speed (100 rpm) and 5 min. at high speed (500 rpm). Put 600 mL dough in a greased baking tin (21.6 x 11.5 x 7.1 cm) and prove for 45 min. at 34°C and 90% relative humidity.

Baking regime

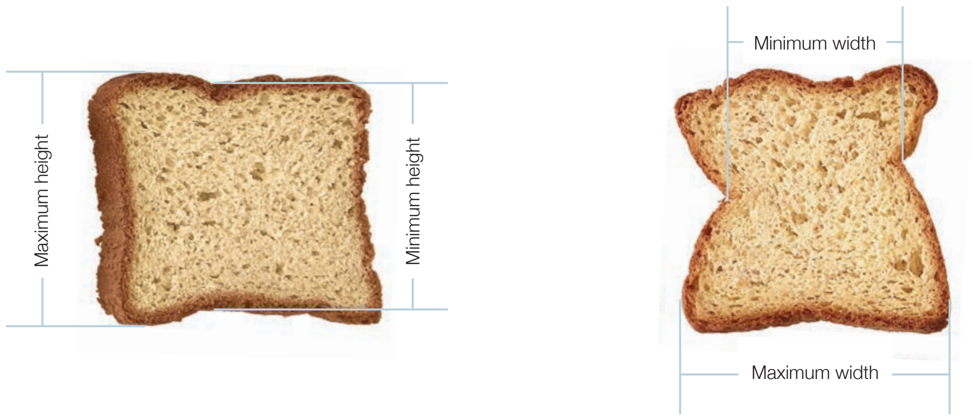
5 min. at 220°C (insert 400 mL steam at start of baking) and 45 min. at 180°C.

Test methods

Loaf deformation

Loaf deformation was measured as height and width of bread slices. To measure the height and width, the loaves were cut into 1.5 cm-wide slices. Six slices per loaf were used. The six slices were taken from defined positions across the loaf. Then two measurements were taken of height (min. and max. height) and width (min. and max. width) per slice (see figure 1). The minimum and maximum measurements were used in order to determine the extent of deformation of the bread.

Figure 1: Schematic explanation of measurements of height and width



Staling/ageing of bread

The objective was to determine whether bread produced using recipes containing xanthan gum were significantly less stale after a predefined storage time under predefined storage conditions compared to the same recipes without the addition of xanthan gum.

Figure 2: Sample measured by Texture Analyzer

For this purpose, all loaves were measured 24 and 72 hours after baking using Texture Analyzer Brookfield CT3 (see figure 2). The loaves were measured using the same method of sample preparation and measurement parameters. Hardness was calculated and compared. Hardness increase over time is a textural attribute related to ageing of bread (Demirkesen et al., 2013).[4]

Sensory evaluation
The objective was to evaluate whether bread produced using recipes containing xanthan gum performed significantly differently with regard to predefined attributes compared with bread produced using the same recipes but without the addition of xanthan gum. The sensory properties of both recipe versions – baked with and without xanthan gum – were evaluated by our internal sensory panel. The samples were provided to the panel one day after baking. The recipes R1 1.5% XG and R1 NXG were tested using a paired comparison and a CATA ("check all that applies") test.

In the paired comparison test the panellists had to choose the sample corresponding better to the following three attributes: freshness, bread-like texture, overall preference.

CATA, the second sensory test, is a descriptive rapid test method. The panellists were provided a list of attributes that are relevant to bread quality (see below), and chose the attributes that applied. In the evaluation of the test, the frequencies of every attribute for each sample were counted and compared.

Attributes for the CATA test are

- fresh
- soft
- bread-like
- tight
- tough
- dry
- stale
- sponge-like
- ball-forming (while chewing)

Results and discussion

Visual appearance

Recipe 1
Comparing the three different tested xanthan gum quantities, the recipe containing 1.5% xanthan gum (R1 1.5% XG) performed best regarding form, volume and crumb structure of the gluten-free bread.

Using only 1% of xanthan gum (R1 1% XG) resulted in poorer volume and a very dense pored crumb structure while using 2% of xanthan gum (R1 2% XG) resulted in greater volume, but also unevenly shaped loaves with concave bottoms and, in places, larger holes in the crumb (see figure 3).

Figure 3: Left R1 1% XG; middle R1 1.5% XG; right R1 2% XG

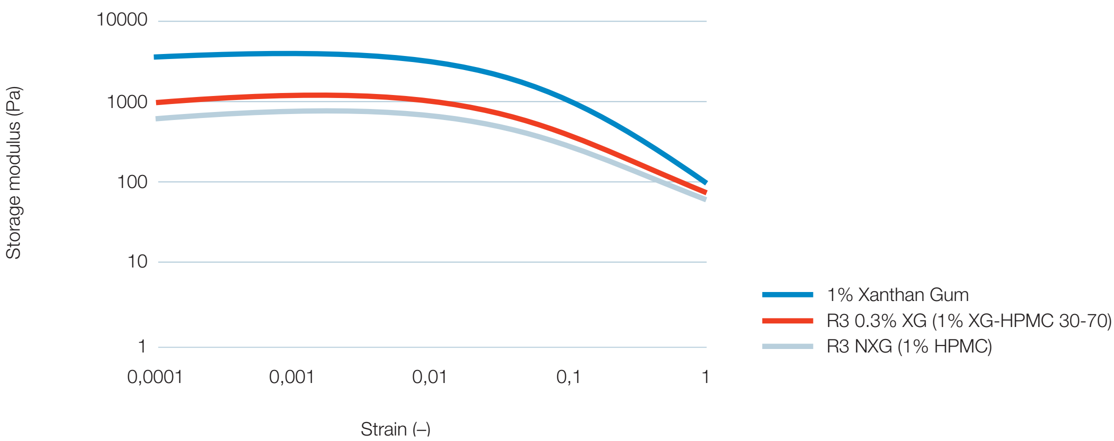
Recipe 3
Xanthan gum was able to stabilise the gluten-free system. While HPMC is known for gaining volume, xanthan gum improves the grain structure of the crumb more than HPMC (Dizlek; Ozer, 2015).[11] The addition of xanthan gum to a recipe containing HPMC improves the handling in baking and results in more evenly shaped loaves. Thus, adding xanthan gum makes the dough less prone to baking faults.

Figure 4: Bread loaf of R3 NXG with side crack

Figure 4 shows the crack all along the side of the loaf that was observed when xanthan gum was not used. The lower elasticity of HPMC compared to the elasticity of xanthan gum (Lazaridou et al., 2007)[5] may explain why the bread containing HPMC only is predisposed to such cracks.

Figure 5 shows the elasticity graphs of gluten-free dough made according to recipe 3, containing either 1% of xanthan gum, 1% of HPMC or the combination of 30% of xanthan gum to 70% of HPMC (1% in total).

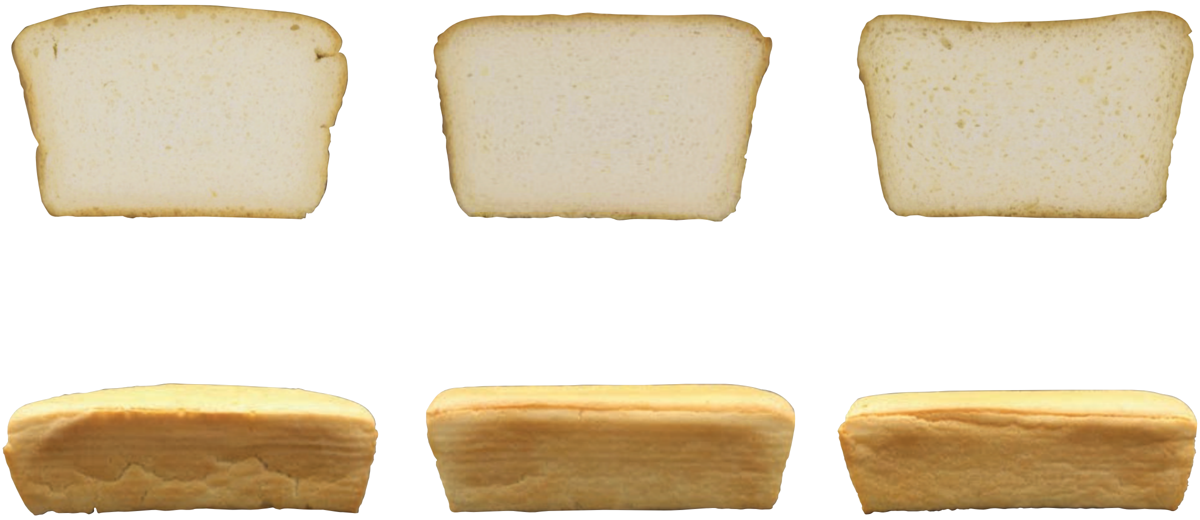
Figure 5: Elasticity comparison of gluten-free dough using xanthan gum, HPMC or a combination



Depending on the added hydrocolloid system, significant differences in dough elasticity were observed. In the case of xanthan gum the dough became much stronger (higher storage modulus value in the linear regime) compared to the same quantity of HPMC (R3 NXG). Already a ratio of 30% xanthan gum to 70% HPMC (R3 0.3% XG) resulted in an increase in the elasticity of the dough.

A comparison of the crumb structure and shape resulting from the three xanthan gum to HPMC ratios tested revealed the huge impact of xanthan gum combined with HPMC. R3 0.2% XG (lowest xanthan gum quantity tested) had the lowest dough elasticity, resulting in a preponderance of baking faults such as side cracks. Furthermore the crumb showed a foam-like and dense structure with fewer and smaller pores (see figure 6a). R3 0.4% XG (highest xanthan gum quantity tested) resulted in loaves with slightly convex tops while the crumb structure became more open with larger and more irregularly-shaped pores (see figure 6c). R3 0.3% XG offered the optimal xanthan gum to HPMC ratio. The evenly shaped loaves showed great volume and a crumb structure with lots of pores of comparable size (see figure 6b). Additionally, the crumb structure of R3 0.3% XG most resembled the structure of gluten-containing bread.

Figure 6: a (R3 0.2% XG) b (R3 0.3% XG) c (R3 0.4% XG)



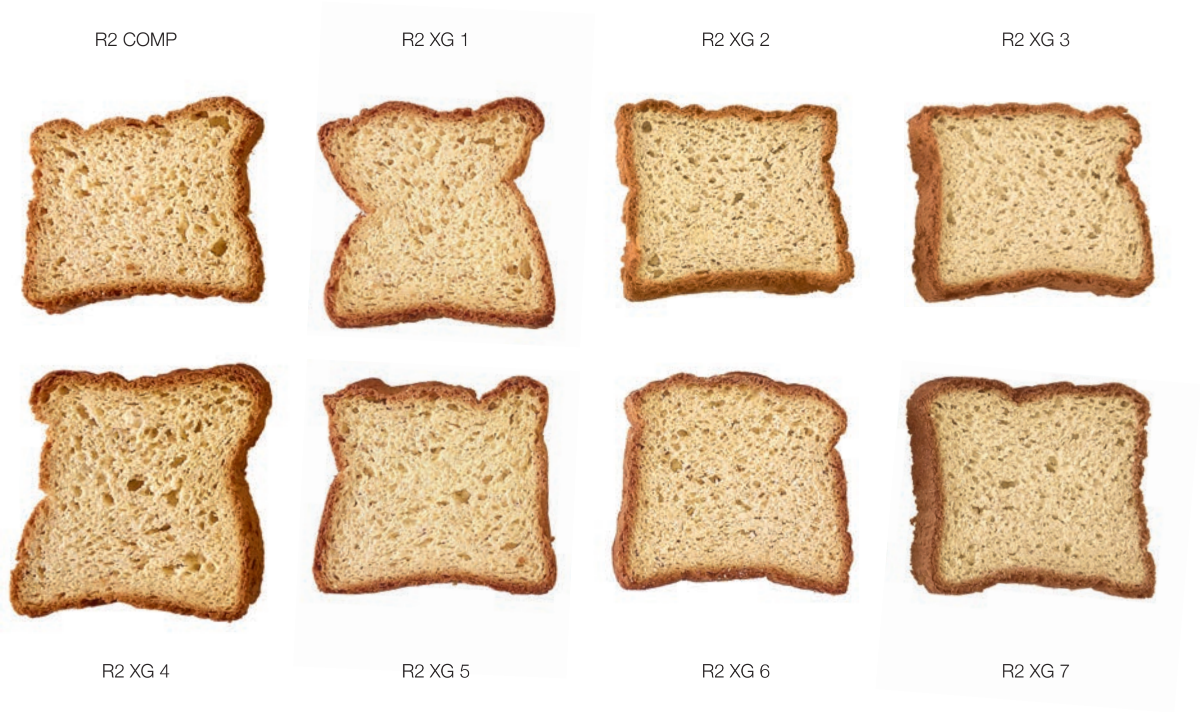
Loaf deformation of recipe 2

Statistical analysis showed that there is a significant difference in minimum and maximum height depending on the xanthan gum type used. R2 XG 1 and R2 XG 4 are made with xanthan types that achieve a significantly better minimum and maximum height compared to the other xanthan gum types used.

Lateral elastic deformations were observed on the loaves and therefore measurements of the width were taken to establish whether these deformations are statistically significant. Statistical analysis revealed two meaningful groups: R2 XG 2, R2 XG 5, R2 XG 6, R2 XG 7, and R2 COMP deformed least, whereas R2 XG 1 and R2 XG 4 deformed most. In conclusion, the xanthan gum types that lead to a significantly higher rise (R2 XG 1 and R2 XG 4) are also the ones that show greater lateral deformation. Xanthan gum types with a lower rise also show less lateral deformation.

Data analysis comparing the single breads with Jungbunzlauer xanthan gum to the bread with competitor xanthan gum shows that R2 XG 6 has a significantly better rise (measured as height) and resistance to deformation (measured as width) than R2 COMP.

Figure 7: Bread slices made with different xanthan gum types



Lateral deformation is not only determined by ingredients but also by the manufacturing process. To limit lateral deformation, process conditions should be explored further.

Depending on the application (e.g. bread or muffin), different recipe and processing conditions in accordance with the type of xanthan gum will be required to optimise baking results.

Staling/ageing of bread

Staling during storage of bread is a very complex mechanism that has a great impact on consumer acceptance. The chemical background of this phenomenon is not yet completely understood, but starch retrogradation and moisture diffusion are clearly related to bread ageing (Ozkoc et al. 2009).[9] Hydrocolloids are able to delay starch retrogradation and to improve moisture retention in food. They can also reduce ageing of gluten-free bread by maintaining the general quality of the product during storage (Stauffer 1990[10]; Rosell et al. 2001[11]).

Recipe 1

The increase in hardness from day 1 to day 3 was 16% lower in R1 1.5% XG compared to R1 NXG. This indicates that xanthan gum significantly delays the staling process.

Recipe 3

By comparing the hardness values of R3 0.3% XG and R3 NXG, it can be concluded that exchanging an amount of HPMC with xanthan gum helps delay the staling process. A 30% xanthan gum to 70% HPMC ratio (total 1%) reduced the staling process from day 1 to day 3 by approximately 20% compared to a recipe containing 1% of HPMC.

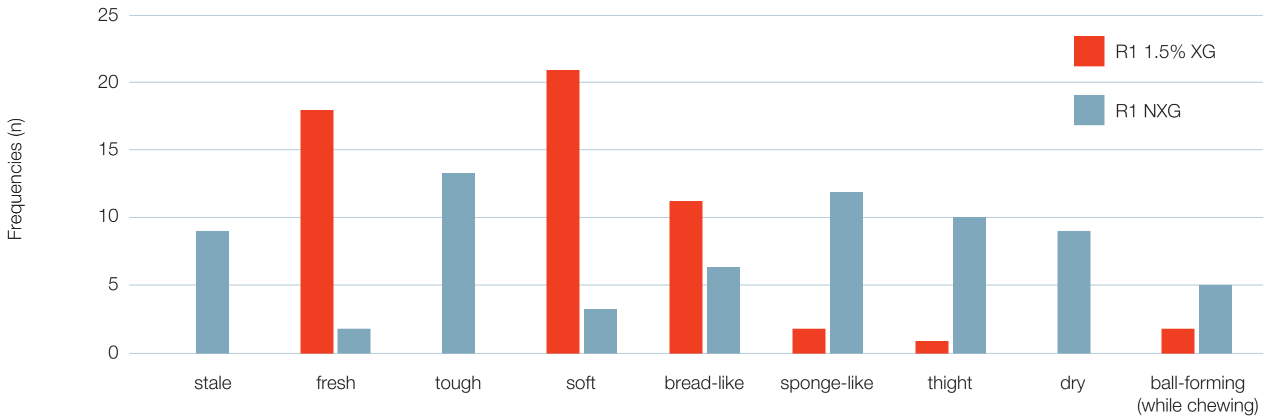
Sensory evaluation of recipe 1

Paired comparison test

R1 1.5% XG was significantly favoured with respect to its bread-like texture, freshness and overall preference (all attributes tested) compared to the same recipe without xanthan gum (R1 NXG).

CATA test

Figure 8: Results of CATA test comparing R1 1.5% XG and R1 NXG



R1 1.5% XG clearly performs better in all attributes mentioned in the CATA test. The xanthan gum containing bread was perceived as less stale, tough and dry, and at the same time more fresh and soft. Also, the texture of the bread with xanthan gum was perceived as more bread-like and less sponge-like.

Conclusion and outlook

Even though gluten-free products are gaining popularity worldwide, producing gluten-free bread that is acceptable in terms of stability and sensory attributes remains a challenge. The gluten network provides many functions that are important for a high-quality end product. The present experiments and many studies clearly show that xanthan gum is one of the best choices to help substitute the gluten network:

Xanthan Gum

- helps delay bread staling/ageing
- helps provide a bread-like structure
- makes the bread less prone to baking faults
- improves handling during the baking process

The current trend for gluten-free bread includes incorporating a large amount of protein (e.g. lentil, chickpea, milk or egg) into the formulation. These ingredients help to improve the dough matrix and its nutritional values but are often limited in their level of use because they tend to add bitter or astringent off tastes. During previous sensory evaluations of other applications we observed that xanthan gum tends to cover or even block these off tastes. Studies have already been conducted to examine the effect of xanthan gum on flavour in certain applications such as beverages and jelly-type desserts (Clark 2002).[12] Further experiments need to be performed in order to predict the impact of xanthan gum on the flavour of different gluten-free bread recipe systems.

Jungbunzlauer can provide additional information and a recipe card for gluten-free bread on request.

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Jungbunzlauer is one of the world's leading producers of biodegradable ingredients of natural origin. We enable our customers to manufacture healthier, safer, tastier and more sustainable products. Due to continuous investments, state-of-the-art manufacturing processes and comprehensive quality management, we are able to assure outstanding product quality. Our mission "From nature to ingredients®" commits us to the protection of people and their environment.

Jungbunzlauer offers different grades of xanthan gum for food applications as well as pharmaceutical and personal care products.

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