

Impact of Dietary Fibers on Moisture and Crumb Firmness of Brown Bread

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Abstract: The purpose of this study was to investigate the influence of different fibers on firmness and water loss of the crumb of brown bread. The tested fibers were sugar beet fiber, cellulose and inulin. The tests were applied during a storage period of three days. Each fiber-supplemented bread showed decreased firmness on the third day after baking and increased water contents during the entire storage period. There were strong negative correlations between the pressure force, applied by a Texture Analyzer and the water content. The highest water retention as well as the lowest firmness rate was measured at cellulose-rich breads. From this study it is claimed that all of the applied fibers effected the staling of brown bread, with cellulose showing the strongest reducing effect on water loss and firming.

Keywords: Brown bread, dietary fiber, firmness, staling, water binding capacity

INTRODUCTION

Dietary fibers are a common and important ingredient of a new generation of healthy food products. Fibers are defined as carbohydrates, precisely polysaccharides which are resistant to digestion and adsorption in the human small intestine, however, with a complete or partial fermentation in the human large intestine. The intake of fibers is known to show some healthy effects, for example reducing the risk of diseases such as diabetes, constipation and high cholesterol (Mandala *et al.*, 2007).

Fibers improve the nutritional value of bread but usually alter the rheological properties of dough and the quality and sensory properties of the final bread product. Breads containing fiber to a greater extent show especially longer shelf life than control samples (Gomez *et al.*, 2003). This is an important aspect because the fast staling of traditional bread is one of the most reasons for bread waste (Moazzezi *et al.*, 2012).

Staling is a very complex aging phenomenon characterized by physical and chemical changing of the crust and the crumb. Crumb staling is generally caused by the retrogradation of starch. Retrogradation is the back-formation of the gelatinized starch into a crystallized structure, which results in a reduced water binding capacity. The water migrates from the crumb into the crust of the bread and water loss occurs (Primo-Martin *et al.*, 2006).

Fibers have higher water holding capacity and water retention than starch. They form a porous network structure made of polysaccharide chains, which hold high amounts of water through hydrogen bonds (Kethireddipalli *et al.*, 2002) or in their capillary structures through surface absorption (Lopez *et al.*, 1996).

It is hypothesized that fibers prevent bread from water loss due to their water holding capacity and thereby affecting the starch retrogradation. The aim of this study is to investigate the effect of different fibers (sugar beet fiber, cellulose and inulin) on bread staling by determining the water loss and crumb firmness of brown bread.

MATERIALS AND METHODS

Bread making process: The basic formula for making a brown bread paste of 4000 g includes: rye flour (type 997) 41.11%; wheat flour (type 550) 13.56%; dried sourdough 1.66%; salt 1.16%; compressed yeast 0.77%; water 40.25% (temperature: ca. 36°C); breadcrumbs 1.16%. Tested dietary fibers were: sugar beet fiber (Fibrex; Nordic Sugar), a rod-shaped cellulose with a mean length of 300 micro-meters (Vitacel, Type: LC 200; J. Rettenmaier and Söhne GmbH + Co. KG) and inulin (Orafti® HPX; Beneo Orafti). The amount of fiber added to the dough was based on the water binding capacity of the respective fiber, calculated for an amount of 320 g extra water added to the whole dough of 4000 g (Table 1). Fibers were soaked in water for half an hour and the fiber-water mixture was added to the other ingredients.

To prepare bread dough, all ingredients were put in a dough mixer (Diosna Dierks and Söhne GmbH, Osnabrück, DE, Model: S20 3G, No.: 426) and mixed on 60 rpm for 5 min and on 90 rpm for 7 min. After a resting time of 30 min, the dough was divided into 1150 g pieces, hand-molded and put into tin pans for 60 min at 35°C and 80% RH for fermentation.

Table 1: Amounts of fibers added to a 4000 g dough according to the water holding capacities of the fibers

| Fiber | Amount of fibers (g) | Water holding capacity (g H ₂ O/g DS) |
|------------------|----------------------|--|
| Sugar beet fiber | 95.0 | 3-3.5 |
| Cellulose | 38.0 | 8.4 |
| Inulin | 160.0 | 2 |

Three control breads and three fiber-containing breads were baked for each measurement. Breads were baked in an electric oven (Wachtel GmbH, Hilden, DE, Model: Winkler-Wachtel CE 416/77H) for 60 min at 180°C. After cooling down at room temperature (20°C) for 2 h, breads were packed into airtight plastic bags and stored at room temperature for 1, 2 and 3 days properly to the time of the measurement.

Evaluation of crumb firmness: Crumb firmness was measured using a TA-XT2 texture analyzer (Stable-Micro-Systems, Surrey, GB) provided with the software “Texture Expert”. Texture measurements were performed according to the standard AACC Method 74-09 (1983) except that a 35 mm diameter cylindrical probe was used. For bread texture determinations, 5 repetitions from each sample were measured at day 1, 2 and 3 after baking.

Evaluation of water loss during storage: The water loss of the bread crumb during the storage period of 3 days was measured by comparing the water contents of the breads on day 1, 2 and 3 after baking. At each day of storage the water content of 3 samples of each bread was determined. Five grams of the bread crumb were weighed and then dried at 103±2°C for 24 h in a drying cabinet (Thermo Fisher Scientific, Langenselbold, DE, Model: T 6120, No.: 746). After this predrying step, the samples were crushed using a grinder (Moulinex, Krups GmbH, Offenbach, DE, Model: D56). They were left in the drying cabinet for additional 2 h for post-drying and weighed again. The water content (as weight loss on drying) was calculated according to the standard of § 64 LFGB (German food law).

RESULTS AND DISCUSSION

Influence of fibers on firmness: The addition of fibers showed significant influences on firmness of the crumb of brown bread (mixture of rye and wheat flour), even the fibers represented different classes of ingredients. Inulin is a polymer of fructose units linked by beta 2, 1 linkages, cellulose is a polymer of glucose in beta 1, 4 glycoside linkage and sugar beet fiber is a mixture of 42% hemicellulose, 28% cellulose, 27% pectin and 3% of lignin.

Despite the different ingredients the firmness of the bread crumb increased with all fibers during storage even in different degrees (Fig. 1).

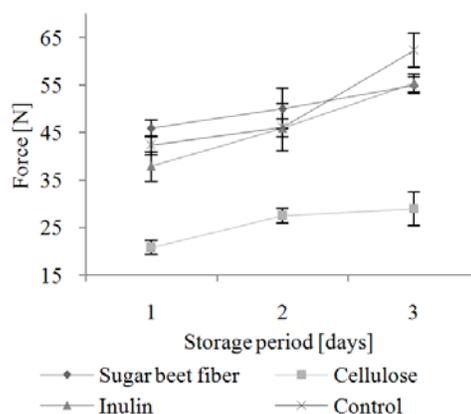


Fig. 1: Influence of different fibers on the evolution of crumb firmness during a storage period of 3 days. Values of each day are averages±S.D. of 5 (sugar beet fiber, cellulose, inulin) and 15 (control) different measurements, respectively

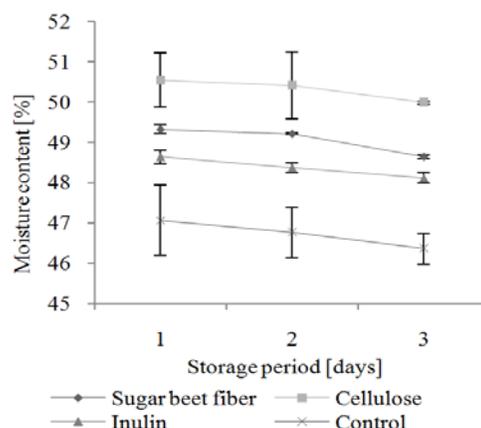


Fig. 2: Influence of different fibers on the evolution of crumb moisture content during a storage period of 3 days. Values of each day are averages±S.D. of 3 (sugar beet fiber, cellulose, inulin) and 9 (control) different measurements, respectively

The lowest firmness was measured in loaves that contained cellulose. Similar effects were first reported by Gomez *et al.* (2003), although those authors examined a spherical cellulose body in white bread, in contrast to the examinations in this study where the cellulose was rod-shaped with a mean length of 300 µm in rye and wheat flour bread. In addition those authors replaced the wheat-flour by the fibers whereas here the fibers were additionally added in water to maintain the process parameter of the used flours.

According to Collar *et al.* (1998), it is assumed that cellulose interferes with the interactions between starch and gluten and thus inhibits the retrogradation of amylopectin. The retarded retrogradation is expressed in a lower firming rate of the bread during storage. In

contrast to cellulose, the addition of sugar beet fiber led to firmer crumbs than the control recipe at day 1, which was also found by Abdul-Hamid and Luan (2000). Gomez *et al.* (2003) suggested that fibers in general may cause firmer crumbs by a thickening effect of the walls that surround the air bubbles in the fiber-added dough even he did not examine inulin and sugar beet fiber as done here. Firmness was not influenced significantly by the addition of inulin at the beginning of the storage period. It is assumed that inulin has a diluting effect on the gluten network resulting in impaired gas retention (Sabanis *et al.*, 2009; Hager *et al.*, 2011). The higher values of firmness may indicate that inulin is not able to interfere with the retrogradation of starch.

Influence of fibers on moisture content: As can be observed in Fig. 2, the added fibers showed a significant effect on the moisture of the breads.

Added cellulose represented the highest value on moisture followed by added sugar beet fiber and inulin. But, in comparison to the control bread, all fiber-rich breads showed higher water contents. This was also shown for other fibers by different authors (Gomez *et al.*, 2003; Guarda *et al.*, 2004; Purhagen *et al.*, 2012; Moazzezi *et al.*, 2012). Purhagen *et al.* (2012) described that the water holding capacity of fibers is larger than that of starch. It is thus supposed that the tested fibers may bond more to water than the starch and prevent the bread from water loss at day 1.

Despite the different moisture levels in the breads as shown in Fig. 2, the rate of dehydration during the three days of storage is quite the same for all fibers and the control bread. In consequence, the water loss of the breads seems to be caused solely by the loss of water of the starch but not by the fibers. This is noteworthy as the fibers represent different classes of ingredients which obviously all fixed the water during storage stronger than the starch for itself. From this point of view fibers may represent a separate body for water in baked bread and have only little or none exchange of water with starch. Therefore, the fibers used in this study have no major effect on the retrogradation of the starch. But this is in contrast with other authors findings (Gomez *et al.*, 2003; Guarda *et al.*, 2004; Goldstein *et al.*, 2010; Purhagen *et al.*, 2012).

The reason for those contradicting findings could be argued by the different method of adding the fibers to the dough. In this study the fibers were suspended in water at the maximum of their water binding capacity and fibers together with their water were provided additionally to dough which was prepared according to a standard recipe with standard water amount. In this way, fibers are not in concurrence with the process water of the dough and therefore do

not restrict the water for the starch as done in other studies.

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