Journal of Microbiology, Biotechnology and Food Sciences

Pastuszka et al. 2012 : 1 (February Special issue) 972-979

REGULAR ARTICLE

IMPACT OF OATS β-GLUCANS ON PROPERTIES OF GLUTEN-FREE BREAD

Dorota Pastuszka, Halina Gambuś, Rafał Ziobro, Krzysztof Buksa, Renata Sabat, Grażyna Augustyn*

Address: University of Agriculture in Krakow, Faculty of Food Technology, Department of Carbohydrate Technology, Balicka Street 122, 31-149 Krakow, Poland

* Corresponding author: d.pastuszka@ur.krakow.pl

ABSTRACT

The aim of the study was to check the potential usability of innovative oats β-D-glucan preparation in the production of gluten-free bakery products. The preparation was used as a partial replacement of hydrocolloid mix used for baking of standard bread. Quality determination included volume, bread yield and total baking loss, and organoleptic assessment by a group of 15 trained panelists. Texture profile analysis was performed using texture analyzer TA.XT Plus. AOAC methods (2006) were used to measure moisture content of the crumb, and contents of β-D-glucan, protein, dietary fiber and its soluble and insoluble fractions.

Keywords: gluten-free bread, β-glucans, quality, nutrition

INTRODUCTION

Celiac disease is characterized by congenital, permanent intolerance to gluten, leading to changes in the structure of the small intestine **(Darewicz and Dziuba, 2007; Niewinski, 2008)**. The only effective way to treat it is to follow a gluten-free diet to eliminate gluten-containing products. Bread used in such treatment is mainly produced from starch of various origins, and may not contain structure forming gluten, which results in a much lower quality of these products, so the studies for new raw materials replacing gluten in the gluten-free dough are continued **(Gallagher *et al.* 2004b; Gambuś *et al.*, 2007; Arendt *et al.*, 2008)**. The group most commonly used for this purpose are hydrocolloids - hydrophilic polymers of plant, animal, microbial or synthetic origin with viscoelastic characteristics suitable for the dough.

β-D-glucans reveal thickening properties (**Lazaridou *et al.*, 2004**), which indicates that it could be used in the production of gluten-free bread as a structure forming component. Attempts to use oat based raw materials for the production of gluten free products seems to be particularly important at the moment, because in accordance with **Commission Regulation (EC) No 41/2009**, the majority of people with gluten intolerance can include them in their diet without negative health effects. However, the use of oat products requires proper preparation and the content of gluten in the final product can not be greater than 20 $mg.kg^{-1}$.

The aim of the study was to check the potential usability of innovative oats β-D-glucan preparation in the production of gluten-free bakery products, as a functional and structure forming ingredient.

MATERIAL AND METHODS

Material

Material for the study consisted of gluten-free breads with varying percentage of an innovative β-D-glucan preparation, produced by FUTURUM Ltd. The applied levels used for dough preparation were 0.5%, 1%, 1.5% and 2.5% per weight of a gluten-free flour. β-D-glucan replaced part of the blend of hydrocolloids added to the standard bread in place of gluten. The preparation contained about 72.3% β-D-glucans as evaluated by HPLC after hydrolysis to monosaccharides **(Buksa *et al.* 2011)**. Before the use for baking β-D-glucan preparation was checked for the content of protein, dietary fiber and β-D-glucans, by standard methods (enzymatic) according to AOAC (2006).

Bread baking

Raw materials used for bread preparation included: corn starch, rice flour, corn flour, potato starch, soy flour, blend of hydrocolloids (hydroxypropylmethylcellulose, guar gum, pectin and locust bean gum in the ratio 2:1:2:1), glucuronic acid lactone, milk powder, yeast, sugar, salt, oil and water. The dough was prepared in an electric mixer type ML 300 (ZBPP, Bydgoszcz, Polska) for 12 minutes. First fermentation was conducted for 20 minutes, and after dividing dough into pieces of 70 g, the second fermentation followed for 15 minutes at 40°C and relative humidity 85% in proving cabinet. Loaves were baked in aluminum pans at 230ºC, in an electric modular oven Miwe Condo, type C – 52 (MIWE, Arnstein, Niemcy), for 20 minutes. After baking the loaves were cooled for 1 hour and used for further analyzes.

Bread quality evaluation

Quality of bread was evaluated by checking mass of the loaves, their volume by rapeseed displacement, and calculating yield and total baking loss **(Jakubczyk and Haber, 1981)**. Organoleptic assessment was performed according to **PN-A-74108:1996**, by a 15-person panel with checked sensory sensitivity. Texture profile analysis was performed with the help of texture analyzer TA.XT Plus, measuring hardness, chewiness, cohesiveness, springiness and resilience of crumb.

Chemical analyzes of bread

Chemical composition of bread, as well as β-D-glucan preparation was checked by the following methods of **AOAC (2006):** water content – 925.10, total protein content – 950.36, dietary fiber (soluble and insoluble fractions) – 991.43, content of β-D-glucan- 995.16.

Statistical analysis

All measurements were done in at least two replicates, and the results were subject to one factor analysis of variance (ANOVA), applying software package Statistica 9.0 (USA). The significance of differences was evaluated by Duncan's test, at $\alpha \leq 0.05$. The results are represented as mean value ± standard deviation (SD).

RESULTS AND DISCUSSION

Gluten free bakery reveals worse quality and nutritional value in comparison to wheat bread. Many authors **(Gambuś *et al.*, 2007; Arendt *et al.*, 2008; Sabanis *et al.*, 2009; Schoenlechner *et al.*, 2010)** points out the necessity to improve technological and nutritional attributes of these products. Because oat based raw materials are allowed in the production of gluten-free food, and pro-health benefits of β-D-glucans are well established, the application of concentrated β-D-glucan preparation as a structure forming agent in gluten-free bread seemed fully justified.

The influence of β-D-glucan preparation on quality and organoleptic attributes of gluten-free bread

The lower levels of β-D-glucan addition (0.5 and 1%) had not significant influence on the change of quality parameters (tab. 1, fig. 1 and 2). The obtained bread had similar mass, volume, yield and total baking loss (tab. 1). Similarly to the samples without β-D-glucans, the loaves were highly appreciated by the consumers and were classified as first quality class. Despite of significantly lower volume, bread with 1.5% share of β-D-glucan preparation was also classified as first quality class (tab. 1). The increase of the level of β-D-glucans to 2.5% resulted in significant deterioration of quality attributes (tab. 1): low volume and dense, non-porous crumb (fig. 1 and 2), which could be attributed to the lack of synergism between hydrocolloids present in the formulation.

Table 1 Quality assessment of the analyzed gluten-free bread

Kind of bread	Weight of cold bread [g]	Bread volume [cm^3]	Bread volume from 100g flour [cm^3]	Yield of bread [%]	Total baking loss [%]	Sensory evaluation	
						Sum of scores	Quality grade
Standard	57.98 ±0.64 a*	262.50 ±12.58 c	752.63 ±36.08 c	166.25 ±1.83 a	17.17 ±0.91 a	39	I
Standard+0.5% β-glukans	57.63 ±1.17 a	272.50 ±15.00 c	780.52 ±42.96 c	165.07 ±3.35 a	17.67 ±1.67 a	39	I
Standard+1% β-glukans	57.83 ±1.80 a	255.00 ±10.00 c	730.76 ±28.66 c	165.72 ±5.15 a	17.39 ±2.57 a	38	I
Standard+1.5% β-glukans	58.46 ±0.40 a	167.50 ±17.08 b	480.25 ±48.97 b	167.62 ±1.14 a	16.48 ±0.57 a	38	I
Standard+2.5% β-glukans	58.38 ±0.64 a	80.00 ±8.16 a	229.26 ±23.40 a	167.31 ±1.83 a	16.60 ±0.91 a	-26	disquali.

*Values in column marked by the different letters are significantly different at $\alpha \leq 0.05$; ±SD

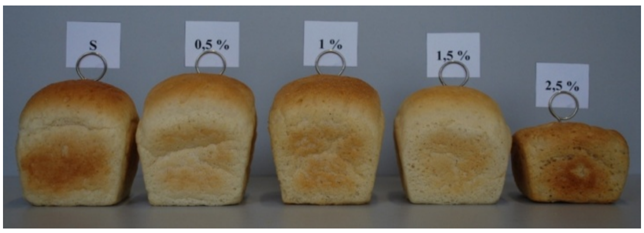

Figure 1 Overall appearance of gluten-free loaves

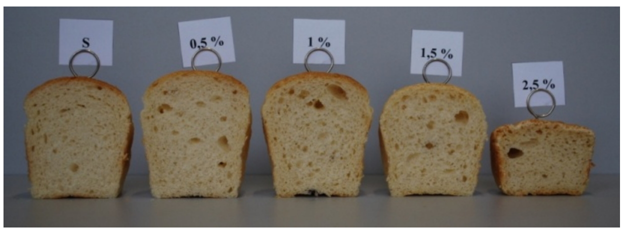

Figure 2 Cross-section of gluten-free loaves

Consumer quality of bakery products is highly affected by crumb texture. Gluten free bread with the share of β-D-glucans not exceeding 1%, revealed comparable moisture and texture parameters as standard bread (without the preparation) (tab. 2). It was however observed, that the addition of such small amounts of β-D-glucans positively influenced crumb cohesiveness, which is manifested in practice as better slicing, and limited crumbling. The increased in the level of β-D-glucans to 2.5% resulted in significant growth of hardness and chewiness, despite elevated moisture of the crumb (tab. 2).

Table 2 Moisture content and texture profile analysis of gluten-free crumb

Kind of bread	Hardness [N]	Springiness	Cohesiveness	Chewiness [N]	Resilience	Moisture of crumb [%]
Standard	2.95 ±0.04 a*	0.96 ±0.02 a	0.58 ±0.02 a	1.64 ±0.12 a	0.31 ±0.03 a	42.31 ±0.25 a
Standard+0.5% β-glukans	2.74 ±0.11 a	0.96 ±0.01 a	0.69 ±0.01 b	1.80 ±0.06 a	0.39 ±0.01 ab	42.69 ±0.40 a
Standard+1% β-glukans	2.73 ±0.03 a	0.96 ±0.01 a	0.68 ±0.00 b	2.06 ±0.02 a	0.34 ±0.01 a	42.95 ±0.37 ab
Standard+1.5% β-glukans	2.78 ±0.22 a	0.98 ±0.02 a	0.76 ±0.02 c	2.08 ±0.06 a	0.45 ±0.02 b	43.47 ±0.04 b
Standard+2.5% β-glukans	12.72 ±0.34 b	0.96 ±0.01 a	0.62 ±0.08 a	7.02 ±1.16 b	0.30 ±0.09 a	44.53 ±0.08 c

*Values in column marked by the different letters are significantly different at $\alpha \leq 0.05$; ±SD

The influence of β-D-glucan preparation on nutritional value of gluten-free bread

Oat β-D-glucans which constituted the major part of the applied preparation were mostly water soluble, and contributed to soluble fraction of dietary fiber. Moreover, the preparation contained some protein residue (tab.3).

Table 3 Content of protein, β-D-glucans and dietary fiber in the analyzed preparation and gluten free bread.

Kind of bread	Total protein (Nx5,7)	β-glukans	Dietary fibre soluble	Dietary fibre insoluble	Dietary fibre total
	g/100g d.m.				
Concentrate of β-glukans	6.15 ±0.08	50.50 ±0.20	56.02 ±0.11	4.01 ±0.22	60.03 ±0.11
Standard	6.54 ±0.02 b	0.06 ±0.01 a	1.87 ±0.02 a	3.25 ±0.06 a	5.12 ±0.09 a
Standard+0.5% β-glukans	6.40 ±0.05 b	0.47 ±0.01 b	2.05 ±0.01 b	3.19 ±0.02 a	5.24 ±0.03 a
Standard+1% β-glukans	5.96 ±0.22 a	0.65 ±0.02 c	2.23 ±0.02 c	3.12 ±0.11 a	5.34 ±0.13 a
Standard+1.5% β-glukans	6.28 ±0.06 b	0.92 ±0.02 d	2.32 ±0.04 c	3.31 ±0.15 a	5.63 ±0.11 b
Standard+2.5% β-glukans	6.46 ±0.05 b	1.31 ±0.02 e	2.27 ±0.05 c	3.40 ±0.04 a	5.66 ±0.09 b

*Values in column marked by the different letters are significantly different at $\alpha \leq 0.05$; ±SD

Small share of protein in the preparation did not affect the level of this constituent in gluten-free bread baked with its share (tab. 3). Each of the applied addition levels resulted in a significant increase of β-D-glucan content in final product. It seems to be especially important from the nutritional point of view, because β-D-glucans display hypoglycaemic activity **(Butt *et al.*, 2008).** Additionally for a considerable group of patients celiac disease is known to coexist with other syndroms, such as diabetes **(Catassi and Fasano, 2008)**. The changes in soluble dietary fiber were not so pronounced, however the increase in this fraction with growing level of β-D-glucan preparation was also observed, as it consecutively replaced other hydrocolloids in gluten-replacing blend.

CONCLUSION

The share of β-D-glucan preparation in blend of hydrocolloids, equivalent to 1.5% of the amount of flour used to bake gluten free loaves, did not affect significantly the qualitative features of the final product, compared with the bread without the participation of this preparation. Larger (2.5%) share of the preparation significantly worsened organoleptic qualities of studied breads. Use of the β-D-glucan isolate significantly increased the content of this healthy ingredient in bread. The product offered by FUTURUM can be used in an amount up to 1.5% by weight of flour, for a production of gluten-free bread following the described technology and formulation. The applicability of a greater share of such preparation requires further study.

Acknowledgments: Work prepared under the special purpose subsidy BM-4709/KTW/2011

REFERENCES

AOAC: Official methods of analysis, 18th edn. Gaithersburg Association of Official Analyyical Chemists International, 2006.

ARENDT E.K. - MORRISSEY A. - MOORE M.M. - DAL BELLO F. 2008. Gluten-free breads. In: Gluten-Free Cereal Products and Beverages. Ed. Arendt E.K., Dal Bello F. *Food Science and Technology, International Series. Elsavier*, 13, p. 289-319.

BUKSA K. - GAMBUŚ H. - NOWOTNA A. - ZIOBRO R. 2011. Chemical composition and molecular properties of innovative preparation of water soluble β-glucan isolated from oat grain. Proceedings of the 7th International Conference on Polysaccharides-Glycoscience Prague 2 – 4 November 2011, ISBN:978-80-86238-90-6, p.80-81.

BUTT M.S. - TAHIR-NADEEM M. - KHAN M.K. - SHABIR R. - BUTT M.S. 2008. Oat: unique among the cereals. In *European Journal of Nutrition*, vol. 47, 2008, no. 2, p. 68-79.

CATASSI C. - FASANO A. 2008. Celiac disease. In: Gluten-Free Cereal Products and Beverages. Ed.. Arendt E.K., Dal Bello F. *Food Science and Technology, International Series. Elsavier*, 1, p.1-27.

COMMISSION REGULATION (EC) No 41/2009 of 20 January 2009 concerning the composition and labelling of foodstuffs suitable for people intolerant to gluten. 21.1.2009 Official Journal of the European Union, L 16/3

DAREWICZ M. - DZIUBA J. 2007. Dietozależny charakter enteropatii pokarmowych na przykładzie celiakii. In *Żywność. Nauka, Technologia, Jakość*, vol. 50, 2007, no. 1, p. 5-15.

GALLAGHER E. - GORMLEY T.R. - ARENDT E.K. 2004. Recent advances in the formulation of gluten-free cereal-based products. In *Trends in Food Science & Technology,* vol. 15, 2004, p. 143-152.

GAMBUŚ H. - SIKORA M. - ZIOBRO R. 2007. The effect of composition of hydrocolloids on properties of gluten-free bread. In *ACTA Scientiarum Polonorum, Technologia Alimentaria,* vol. 6, 2007, no. 3, p. 61-74.

JAKUBCZYK T - HABER T. 1981. Analiza zbóż i przetworów zbożowych. Skrypt SGGW Akademii Rolniczej w Warszawie.

LAZARIDOU A. - BILIADERIS C.G. - MICHA-SCRETTAS M. - STEELE B.R. 2004. A comparative study on structurefunction relations of mixed-linkage (1→3), (1→4) linear β-d-glucans. In *Food Hydrocolloids*, vol. 18, 2004, no. 5, p. 837–855.

NIEWINSKI M.M. 2008. Advances in Celiac Disease and Gluten-Free Diet. In *Journal of The American Dietetic Association*, vol. 108, 2008, no. 4 , p. 661-672.

PN-A-74108:1996. Pieczywo – Metody badań. Polski Komitet Normalizacyjny.

SABANIS D. - LEBESI D. - TZIA C. 2009. Effect of dietary fibre enrichment on selected properties of gluten-free bread. In *LWT – Food Science and Technology*, vol. 42, 2009, no. 8, p. 1380-1389.

SCHOENLECHNER R. - MANDALA I. - KISKINI A. - KOSTAROPOULOS A. - BERGHOFER E. 2010. Effect of water, albumen and fat on the quality of gluten-free bread containing amaranth. In *International Journal of Food Science and Technology*, vol. 45, 2010, no. 4, p. 661-669.