NAUKI INŻYNIERSKIE I TECHNOLOGIE ENGINEERING SCIENCES AND TECHNOLOGIES
2(21) • 2016

ISSN 2080-5985
e-ISSN 2449-9773

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EFFECT OF NAKED BARLEY ENRICHMENT ON THE QUALITY AND NUTRITIONAL CHARACTERISTICS OF BREAD – PART II. THE EFFECT ON RYE BREAD

WPŁYW WZBOGACANIA JĘCZMIENIEM NAGIM NA JAKOŚĆ I WARTOŚĆ ŻYWIENIOWĄ PIECZYWA – CZĘŚĆ II. WPŁYW NA PIECZYWO ŻYTNIE

DOI: 10.15611/nit.2016.2.04
JEL Classification: L66

Summary: The incorporation of naked barley to bread and different bread production methods significantly influenced the dietary fibre content and composition and the quality of wheat bread. Rye flour properties and rye bread production methods affect the bread quality and composition. The aim of the study was to analyse the effects of different naked barley wholemeal share and rye dough preparation methods on bread quality and its nutritional composition. Barley enriched rye bread had significantly increased concentration of soluble and insoluble dietary fibre, insoluble arabinoxylans and β-glucans. Barley incorporation did not affect breads' overall acceptability, but over 30% barley share caused a decrease in loaf volume and changed breads' colour. Two-phase produced breads had higher volume, yet single-phase method breads contained more total and soluble dietary fibre.

Keywords: hull-less barley, rye bread, sourdough, dietary fibre, β-glucans, non-starch polysaccharides.

Streszczenie: Różne udziały jęczmienia nagoziarnowego oraz różne metody produkcji ciasta istotnie wpłynęły na zawartość i skład błonnika pokarmowego oraz jakość pieczywa żytnio-jęczmiennego. Właściwości mąki żytniej i metody produkcji pieczywa żytniego przyczyniły się do zmian w jaości i składzie pieczywa. Celem badań była analiza wpływu różnych udziałów całoziarnowej mąki jęczmiennej i metod prowadzenia ciasta na jakość i skład pieczywa. Pieczywo żytnie wzbogacane jęczmieniem nagoziarnowym cechowało się istotnie zwiększoną zawartością rozpuszczalnego i nierozpuszczalnego błonnika pokarmowego, nierozpuszczalnych arabinoksylanów i β-glukanów. Dodatek jęczmienia nie wpłynął na akceptowalność pieczywa, jednak jego udział powyżej 30% spowodował zmniejszenie

objętości chleba i zmiany jego barwy. Pieczywo wytworzone metodą dwufazową miało większą objętość, natomiast pieczywo uzyskane metodą jednofazową zawierało więcej błonnika pokarmowego rozpuszczalnego i ogółem.

Słowa kluczowe: jęczmień nagoziarnowy, pieczywo żytnie, zakwas, błonnik pokarmowy, β-glukany, polisacharydy nieskrobiowe.

1. Introduction

The use of barley for bread production has decreased due to its poor baking performance and low sensory quality of the products [Izydorczyk, Dexter 2008: Jacobs et al., 2008; Skendi et al., 2010]. However, barley is gaining popularity due to producers and consumers knowledge of its composition and nutritional benefits [Izydorczyk, Dexter 2008]. Barley may be a rich source of dietary fibre and non-starch polysaccharides in diet and growing demand for nutraceuticals and functional foods may result in a further increase in its use for food production [Holtekjølen et al. 2008b; Kinner et al. 2011; Storsley et al. 2003]. Since barley products have influence on both technological and nutritional quality of products, therefore numerous studies were taken on the possibility to use barley in breads [Collar, Angioloni 2014; Holtekjølen et al., 2008b; Izydorczyk et al. 2008; Jacobs et al. 2008; Skendi et al. 2010].

Naked (hull-less) barley is a good source of both soluble and insoluble fractions of dietary fibre. The most valuable of the soluble dietary fibre in barley are mixed-linkage (1→3, (1→4)-β-D-glucans. Naked barley contains significantly higher amount of total β-glucans and lower amount of insoluble dietary fibre than hulled barley genotypes [Kinner et al. 2011]. Barley's non-starch polysaccharides contribute to reduction of serum cholesterol, glycaemic index and the related risks for chronic diseases [Storsley et al. 2003].

β-glucans are capable of forming solutions of high viscosity which is known to be responsible for beneficial physiological effects [Skendi et al. 2010]. β-glucans from barley and oat are proven to lower the glycaemic index and plasma cholesterol and decrease the risk of colon cancer [Dickin et al. 2011; Izydorczyk et al. 2008; Skendi et al. 2010]. Barley, as well as rye, contains high amounts of arabinoxylans. Those non-starch polysaccharides also have the ability to form viscous solutions that slows the rate of digestion in monogastrics. Therefore, it is presumed that they may have similar physiological effects to β-glucans [Izydorczyk et al. 2008; Storsley et al. 2003]. It has been shown that water soluble arabinoxylans from maize, wheat and rye have a positive impact on cecal fermentation, production of short-chain fatty acids and serum cholesterol reduction [Izydorczyk, Dexter 2008].

Rye bread is recommended as an important part of the diet as a good source of dietary fibre, including arabinoxylans and biologically active substances. Rye bread production involves sourdough fermentation which is gaining popularity by the

demand for more natural, healthy and tasty products [Arendt et al. 2007; Zieliński et al. 2008]. Sourdough fermentation affects bread's texture and taste by flavour compounds formation, as well as its nutritional value [Banu et al. 2010; Bondia-Pons et al. 2009; Gänzle 2014; Michalska et al. 2008]. Sourdough bread quality is determined by parameters such as fermentation temperature, dough yield, or the amount and composition of the starter culture, which resulted in the development of new fermentation technologies and the use of starter cultures with defined metabolic characteristics [Arendt et al. 2007; Gänzle 2014].

The incorporation of naked barley to wheat bread formula and different bread production methods strongly affected the quality of bread and its nutritional composition. Rye flour composition and different rye bread production methods have significant impact on bread quality and cereal nutrients. Therefore, the aim of the study was to investigate the effects of different naked barley flour share and dough preparation methods on bread quality and the dietary fibre and non-starch polysaccharides content and solubility.

2. Materials and methods

2.1. Materials

Experimental hull-less barley genotype (STH 4933) supplied from Plant Breeding Strzelce Ltd. IHAR Group, Poland) was used in the study. Barley was milled in Hagberg Perten's Mill (Lab Mill type 120) to obtain wholemeal flour. Rye flour type 720 from Diamant Stradunia Mill Ltd. (Stradunia, Poland) was used for dough formulations. Depending on the bread production method baking acid paste Uldo Sauer 2% from Uldo (Wrocław, Poland) and lyophilised Saf Levain LV2 starter cultures supplied by Lesaffre Bio-Corporation Inc. (Łódź, Poland) were used. Blends of rye flour and wholegrain hull-less barley flour were prepared by substituting rye flour with barley flour at 20, 30 and 40% levels. Control rye breads were made to evaluate the effect of barley incorporation.

2.2. Dough formulations and bread baking

0/100, 20/80, 30/70, 40/60 barley and rye flour blends were used in laboratory breadbaking, 300 grams of flour or blend was used for one loaf. Doughs were prepared with water addition in amounts allowing obtaining 250 FU consistency, yeast- 3g/100g and salt- 1.5g/100g of flour or flour blend. Brabender farinograph (Duisburg, Germany) was used for dough mixing. The doughs were prepared by using two methods: single-phase and two-phase (detmold) method.

The doughs prepared using single-phase method additionally contained 5g/100g rye flour of Uldo acid paste and were fermented in a baking tin for 90 minutes in

30°C and 85% relative humidity in fermentation chamber Eka KL 864 (Eka, Padova, Italy), then kneaded and left for final fermentation. The two-phase method was based on rye sourdoughs fermented by LV2 starter cultures (performance of sourdough: 180, fermentation time: 18 hours, temperature: 27°C, 0.5% of starter). The doughs consisted of sourdough (50% of rye flour), remaining components of the flour blend and water, yeast and salt in the same amounts as in the single-phase method. After mixing the two-phase doughs were placed in a baking tin for final fermentation in 30°C.

The loaves were baked in a laboratory oven (Brabender, Duisburg, Germany) for 35 minutes in 240°C in both dough preparation methods. Baking experiments were performed twice and their averages were reported in the study. After 24 hours breads' properties were evaluated and the samples of each bread was freeze-dried and milled for non-starch polysaccharides content analysis.

2.3. Characteristics of bread

Breads were evaluated in terms of loaf volume, colour and sensory properties. Breads' volume was measured by millet displacement method using the SA-WY device (ZBPP, Bydgoszcz, Poland), and expressed in cm^3 per 100 g of flour. Breads' crust and crumb colour were measured with L*, a* and b* values at five different points of the slice (crumb) and loaf surface (crust) using Minolta Colorimeter (CR-400/410, Konica Minolta, Japan). Ten panelists evaluated the sensory properties of breads using 9-point hedonic scale. The average ratings of breads' external appearance, crumb colour, porosity, flavor and taste were expressed as the overall acceptability.

2.4. Dietary fibre and non-starch polysaccharides content

Total, soluble and insoluble dietary fibre content were determined by the enzymatic-gravimetric AOAC method [AOAC, Method 991.43, 2006]. For the determination of total, soluble and insoluble arabinoxylans content the colorometric method described previously [Pejcz et al. 2015] was used. The β-glucan concentration was determined with the use of mixed linkage β-glucan assay kit (Megazyme International, Bray, Ireland) following the ICC Standard Method No. 166. The averages of all determinations performed in duplicate were reported in the study.

2.5. Statistical analysis

The results were statistically analysed with Statistica 12.0 software package (StatSoft, Tulsa, USA). One-way ANOVA at $p = 0.95$ was calculated and homogeneous groups according to Duncan test were estimated.

3. Results and discussion

3.1. Characteristics of bread

Different barley share and dough preparation method influenced breads' quality (table 1). In recent study 30% and more barley share negatively affected the loaf volume, while 20% did not. It was reported that barley addition to bread resulted in deterioration of bread's quality and reduction of loaf volume [Blandino et al. 2015; Collar, Angioloni 2014; Holtekjølen et al. 2008b; Jacobs et al. 2008]. Bread's volume depression is associated with increased amount of dietary fibre and it was proven that high concentration of β-glucans and insoluble arabinoxylans caused deterioration of breads' quality features [Collar, Angioloni 2014; Courtin, Delcour 2002; Holtekjølen et al. 2008b; Izydorczyk, Dexter 2008]. Breads obtained using two-phase method comparing to single-phase method had significantly higher loaf volume. Tamani et al. [2013] also observed a positive impact of lactic acid bacteria fermentation on bread volume since sourdough fermentation increases gas retention capacity of the dough.

Table 1. The volume, colour and acceptability of rye-barley bread depending on the share of barley and the bread making method
Tabela 1. Objętość, barwa i akceptacja pieczywa żytnio-jęczmiennego w zależności od udziału jęczmienia i metody wytwarzania

		Loaf volume [cm^3]	Crust colour			Crumb colour			Overall acceptability
			L*	a*	b*	L*	a*	b*	
Barley share	0%	348 a	39.25 b	11.09 a	17.43 b	58.76 a	1.41 c	18.33 a	6.2 a
	20%	339 a	40.42 b	10.63 a	17.82 b	56.25 b	1.80 b	16.70 b	5.8 a
	30%	317 b	43.03 a	9.40 b	20.05 a	54.90 b	2.02 a	16.13 c	5.4 a
	40%	312 b	42.48 a	8.89 b	21.11 a	54.79 b	2.05 a	15.35 d	5.5 a
Bread making method	Single-phase	315 b	43.96 a	9.50 b	21.79 a	57.47 a	1.57 b	17.22 a	5.7 a
	Two-phase	343 a	38.63 b	10.50 a	16.42 b	54.88 b	2.07 a	16.04 b	5.8 a

Data represent the mean of two (loaf volume), five (colour parameters) or ten (sensory analysis) replicates. Small letters denote significant groups according to Duncan's test, $p = 0.95$.

Source: own work.
Źródło: opracowanie własne.

Bread's colour affects its desirability. The colour of the crust compared to the crumb was darker and more saturated (lower L*, the higher a* and b* values). Barley wholemeal incorporation at 30% and 40% resulted in darker (L*), more yellow (b*) and less red (a*) crust comparing to control rye bread and bread with 20% barley share. The crumb of rye-barley breads was darker than control bread's regardless of the level of substitution. In contrast to the crust colour, the shade of crumb turned more red (a*) and less yellow (b*) with increasing barley share. A decrease in bread's

brightness caused by barley products addition has been reported in case of wheat bread [Blandino et al. 2015; Gill et al. 2002; Holtekjølen et al. 2008a; Izydorczyk et al. 2008; Trogh et al. 2004]. Skendi et al. [2010] studied the effect of isolated barley β-glucan addition and observed that the L* values of bread crumbs decreased significantly with increasing level of β-glucans. Blandino et al. [2015] and Holtekjølen et al. [2008a] also obtained increased a* values of barley enriched breads. The colour of both the crust and the crumb was brighter, less red and more yellow in single-method produced breads comparing to two-phase.

Despite the lack of statistically significant differences barley incorporation to bread resulted in a slight deterioration in bread's overall acceptability. However, similar scores obtained by different barley share and different method produced breads indicates that good quality bread can be obtained by partial substitution of rye flour by barley wholemeal, while improving its health beneficial properties.

3.2. Dietary fibre and non-starch polysaccharides content

Naked barley wholemeal is a good source of both soluble and insoluble dietary fibre. With increasing barley share both fibre fractions content increased significantly at every level of substitution (table 2). The results of Collar and Angioloni [2014] showed that using 15% share of naked barley in wheat bread significantly promotes total as well as soluble dietary fibre contents in bread. Izydorczyk et al. [2008] obtained an acceptable flat bread with increased total and soluble dietary fibre content and decreased starch digestibility using the 20% addition of barley fibre rich fractions to wheat flour.

Table 2. The content of dietary fibre, arabinoxylans and β-glucans depending on the barley share and bread making method [% d.m.]
Tabela 2. Zawartości błonnika pokarmowego, arabinoksylanów i β-glukanów w zależności od udziału jęczmienia i metody wytwarzania pieczywa [s.m.]

		Dietary fibre			Arabinoxylans			β-glucans
		total	insoluble	total	insoluble	total	insoluble	
Barley share	0%	7.08 d	5.61 d	1.47 d	5.96 c	4.81 b	1.15 ab	0.76 b
	20%	8.05 c	6.17 c	1.88 c	6.2 b	4.99 b	1.21 a	1.88 a
	30%	8.95 b	6.77 b	2.18 b	8.4 a	7.20 a	1.20 a	1.88 a
	40%	10.26 a	7.89 a	2.37 a	8.67 a	7.59 a	1.08 b	2.03 a
Bread making method	Single-phase	8.80 a	5.47 b	3.33 a	6.35 b	5.17 b	1.18 a	1.62 a
	Two-phase	7.78 b	6.16 a	1.62 b	10.12 a	8.98 a	1.14 a	1.66 a

Data represent the mean of two replicates. Small letters denote significant groups according to Duncan's test, $p = 0.95$.

Source: own work.
Źródło: opracowanie własne.

In rye bread making both water soluble and insoluble arabinoxylans have important functional properties. Both rye and barley are rich source of arabinoxylans. Total arabinoxylans content increased significantly at 20% and 30% barley flour share, water insoluble arabinoxylans concentration increased at 30% barley share, while soluble arabinoxylans content decreased at 40% of barley substitution. Low solubility of barley arabinoxylans were also reported by Izydorczyk et al. [2008].

Naked barley is becoming popular for food purposes due to high β-glucan concentration. The increased levels of β-glucan in barley enriched baked products has been confirmed by other researchers [Blandino et al. 2015; Collar, Angioloni 2014; Izydorczyk et al. 2008]. In present study 20% naked barley addition caused a significant increase in β-glucan concentration, while further increasing barley share did not have such a substantial impact.

The single-phase method resulted in higher concentration of total and soluble dietary fibre, while two-phase method obtained breads contained more insoluble dietary fibre, total and insoluble arabinoxylans. The soluble fraction of arabinoxylans and β-glucans content in breads was not affected by bread production method. High soluble arabinoxylans content improves baking performance and bread's volume [Buksa et al. 2013]. However, scientific reports showed that sourdough fermentation resulted in an increase of arabinoxylans solubility [Boskov-Hansen et al. 2002; Gänzle 2014; Katina et al. 2007].

4. Conclusion

Naked barley enriched rye bread is characterized by increased content of both soluble and insoluble dietary fibre, insoluble arabinoxylans and particularly essential β-glucans. Barley wholemeal did not affect breads' overall acceptability by sensory panel, however, over 30% barley share led to a change in breads' colour and decrease in loaf volume. Single-phase produced breads contained more total and soluble dietary fibre, yet two-phase method resulted in higher volume.

5. Acknowledgements

This work was financed by National Science Centre within the research project No. N N312 446340.

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