INVESTIGATION OF TOTAL DIETARY FIBER, B_1 AND B_2 VITAMIN CONTENT OF FLOUR BLEND FOR PASTA PRODUCTION

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Abstract

The main purpose of the current research was to investigate total dietary fiber and vitamin B_1 and B_2 content in flour blends made from several types' whole grain flour for pasta production. In 2012 harvested convectional rye 'Kaupo', wheat 'Zentos', hull-less barley line 'PR 5099' and triticale line '9405-23' grain and, for flour blends obtaining, wheat flour type 550 was used in the experiments. Following quality parameters of flours using standard methods was evaluated: total dietary fiber content (ISO 5498) and vitamins B_1 and B_2 – by AOAC 986.27 and 970.65 respectively. In the present research significant differences in total dietary fiber of analysed whole grain rye, hull-less barley, triticale and wheat flour samples were established. Higher dietary fiber content was found in whole grain hull-less barley and rye flour, the lowest in the wheat flour type 550. Lower dietary fiber content was obtained for whole wheat and triticale flour blends. However, the higher, for whole rye and hull-less barley flour blend. B_1 vitamin content in whole grain rye and wheat flour was significantly higher than in hull-less barley and triticale. Lowest vitamin B_2 content was obtained in wheat flour type 550. Lower B_1 vitamin content, as 2.70±0.14 mg kg^{-1} was obtained for whole hull-less barley flour blend, the higher as 3.19±0.28 mg kg^{-1} for whole wheat flour blend. Lower B_2 vitamin content, as 0.91±0.06 mg kg^{-1}, was obtained for whole hull-less barley flour blend, however, the higher B_2, as 0.81±0.28 mg kg^{-1} in whole wheat flour blend.

Keywords: grain, vitamins, dietary fibre, pasta, flour blends.

Introduction

Cereals and their products constitute an important part of the human diet, providing a high proportion of carbohydrates, proteins, fats, dietary fibres, B group vitamins and minerals (Okarter et al., 2010).

Whole grains include cereal grains that consist of the intact, or ground, cracked or flaked fruit of the grains whose principal components are present in the same proportions as they exist in the intact grain containing a higher fiber, minerals and antioxidants (Slavin, 2004; Franz et al., 2006; Liu, 2007). Consumption of whole grain foods has been associated with decreased risk of cardiovascular disease and certain cancers, favourable effects on blood lipids and glucose, improved insulin resistance, and higher intakes of dietary fiber and micronutrients (McKeown et al., 2002). However, an understanding of optimal whole grain consumption levels, as well as the mechanisms by which whole grain foods exert their favourable effect's is unclear (Lang et al., 2003; Slavin, 2003). Health benefits are associated with an increased intake of dietary fiber, including a reduced risk of coronary heart disease, diabetes, obesity, and some forms of cancer, as well as a reduction in cholesterol and fat (Anderson et al., 2009a; Brownlee, 2011).

Dietary fiber has an outstanding application as one of the key nutritional factors in the frame of a healthy diet. Dietary fiber remains a nutritional concept and comprises the edible part that escapes digestion in the small intestine and passes into the large intestine intact (Anderson et al., 2009a,b; Brownlee, 2011). Dietary fiber consists of non-starch polysaccharides such as arabinoxylans, cellulose, and many other plant components such as resistant starch, resistant dextrins, inulin, lignin, waxes, chitins, pectins, β-glucans, and oligosaccharides (Gaoshuang et al., 2012).

Thiamine is known to occur in the outer integuments and germ of cereal grain. In wheat grain, the endosperm represents 80–85% of grains dry mass (DM), but contains only 3% of the total thiamine. The highest proportion (80%) of thiamine is found in the external layers of wheat grain, but these are missing in white flour (Batifloulier et al., 2006). In the scientific literature are mentioned study reports on the thiamine and riboflavin contents of some Finnish cereal products including rye flour, crispbreads, and breakfast cereals, as well as their contents in some imported crispbreads and breakfast cereals sold in Finland. The mean thiamine contents of Finnish rye meal and flour (ash content 0.9–1.2%) were 0.28±0.01 and 0.27±0.04 mg 100 g^{-1} fresh weight (FW), and their respective riboflavin contents were 0.10±0.01 and 0.08±0.02 mg 100 g^{-1} FW. The thiamine contents of domestic crispbreads were 0.27±0.03 mg 100 g^{-1} FW, and the riboflavin contents were 0.16±0.05 mg 100 g^{-1} FW, which is significantly higher than levels in imported products. The thiamine contents of muesli and other breakfast cereals averaged 0.29±0.07 and 0.40±0.15 mg 100 g^{-1} FW, respectively, and their riboflavin contents averaged 0.19±0.23 and 0.21±0.50 mg 100 g^{-1} FW, respectively (Hägg et al., 1993).

Whole wheat flour, one of the most common and important whole grains, retains wheat bran and germ and acts as a rich source of dietary fibre, vitamins, minerals and antioxidants (Wang et al., 2014). Rye is second to wheat, the most commonly used grain in the food. Among the grain, rye is the only one with a wholegrain culture, and the consumption of rye should be increased in light of this benefit. In general, rye could be exploited more efficiently in new types of cereal products due to its positive health effects. Nowadays, its use is limited mainly as a result of the problems arising from its flavour; not all European consumers are familiar with the somewhat foreign, rye-like flavour, perceived as bitter and intense.

However, rye consumption in Europe might increase if ingredients were produced with the specific rye-like flavour modified to a slightly milder one, without significantly decreasing the contents of fibre and bioactive compounds in the rye. In general, volatile compounds that influence the cereal flavour have been extensively studied, but the sensory perception and, in particular, the methods of modifying the flavour of rye are not well known. With regard to the different flavour of the fractions of a rye grain, milling fractionation could be a valuable processing technique for modifying the rye-like flavour in the desired direction (Heiniö et al., 2003).

Triticale is a type of small grain created by genetically combining wheat and rye. Triticale grain, flours, and prepared products are available through both health food and commercial outlets on a limited basis. The data indicate that while the nutritional quality of triticale is considered superior to wheat, the higher ash content, lower milling yields of flour, and inferior loaf volume and texture distract from commercial baking use of triticale. In comparison with bread wheat, triticale has low gluten content, efficient gluten viscoelasticity and, therefore, inferior bread-making quality (Doxastakis et al., 2002).

Hull-less barley has been intensively investigated in respect to its food, feed and industrial applications. The advantage of hull-less barley compared to hulled barley in food uses is that pearling is not needed, so that the outer part of the endosperm, the aleurone, which contains proteins with essential amino acids and vitamins, is retained, as well as other bioactive compounds. It can be milled using conventional equipment available for wheat milling, with extraction yields of 73%. Hull-less barley flour has been successfully used in chemically leavened products such as muffins, pancakes, biscuits and cookies (Andersson et al., 2009a,b).

Traditionally, pasta is manufactured solely from durum wheat, which results in a product considered to be of superior quality to pasta made from cheaper common wheat or a blend of the two species. The manufacture of pastas from mixtures of durum and common wheat without adequate labelling is usually considered as adulteration. Durum wheat pasta for export outside the European Union may contain a maximum of 3% common wheat from unavoidable adventitious contamination during agricultural processing. Pasta is consumed in large quantities throughout the world. Scientific research has been undertaken to understand the parameters influencing pasta processing and the final product quality. Ideally, cooked pasta is of al dente quality. It is firm and resilient with no surface stickiness and little if any cooking losses (Sissons et al., 2005; Troccoli et al., 2000).

In the scientific literature practically was not found data about whole grain flour made form hull-less barley, rye, triticale and wheat application in pasta production, as well as dietary fibre and B_1 and B_2 vitamins content of possible whole flour blends for pasta making.

The main purpose of the current research was established to investigate total dietary fiber and vitamin B_1 and B_2 content in flour blends made from several types' whole grain flour for pasta production.

Materials and Methods

The study was realised at the scientific laboratories of Faculty of Food Technology at Latvia University of Agriculture (LLU) and at the laboratory of the JSC Jelgavas dzirnavas (Latvia), at the laboratories of Latvia University Institute of Biology (Latvia).

Characterisation of raw materials

In 2012 harvested from State Priekuli Plant Breeding Institute (Latvia) convectional rye ('Kaupo'), hull-less barley (line 'PR 5099') and triticale (line '9405-23'), as well as form LLU research station „Peterlauki" (Latvia) wheat ('Zentos') grain was used in the experiments. For the flour blend obtaining wheat flour 550 type (Latvia) was used.

Before experiments grain were grounded in laboratory mill Hawos (Hawos Kornmuhle GmbH, Germany) obtaining fine whole grain flour.

Preparation of flour blend samples

Whole grain blend proportions was pre-selected for the analysis of finished products − pasta. At the previous experiments optimal wheat flour 550 type and whole grain flours ratio was obtained as follow: 70% wheat flour 550 type and 30% whole wheat flour (W/W); 80% wheat flour 550 type and 20% whole rye flour (W/R); 70% wheat flour 550 type and 30% whole triticale flour (W/T); 80% wheat flour type and 20% whole hull-less barley flour (W/H). As a control sample wheat flour 550 type was analysed.

Analysed parameters

Total dietary fiber content was measured by Fibertec system 1010 Heat Extractor corresponding to ISO 5498. Flour blend added 50 mL Phosphate buffer solution, pH 6.0, to each flask. The testing procedure was as follow: check pH and adjust if necessary to pH 6.0±0.2 by adding 0.275N NaOH or 0.325N HCl. Added 100 µL of Alpha amylase. Cover flasks with Aluminium foil and incubate in boiling water bath for 30 minutes. Adjust to pH 7.5±0.2 by adding 10 mL 0.275N NaOH than add 100 µL Protease solutions to each flask. Cover flasks with Aluminium foil and incubate in boiling water bath for 30 minutes at 60±1 °C. Dispense 10 mL 0.325N HCl into flasks while stirring. Adjust to pH 4.0-4.6. Add 200 µL Amyloglucosidase solutions while stirring. Cover flasks with Aluminium foil and incubate in boiling water bath for 30 minutes at 60±1 °C. To each digested sample added 280 mL 60 °C hot 95% Ethanol OH. Measure the volume of Ethanol OH prior to heating. Remove from bath and cover flasks with Aluminium foil. Let precipitate for 1h at room temperature. Wet and redistribute Celite bed in previously tarred crucible using a few mi 78% Ethanol OH from wash bottle.

Apply suction to draw Celite onto fritted glass as an even mat. Attach the crucibles and the Incubation flasks to the Fibertec E, Filtration Module according to instructions under section Filtration in AN 302. Filter alcohol-treated enzyme digested through crucible. Using wash bottle with 78% EtOH and rubber spatula transfer all remaining particles to crucible.

Vitamins B_1 and B_2 content was measured by AOAC Official methods 986.27 and 970.65 respectively.

Mathematical data processing

Data are expressed as mean ± standard deviation; for the mathematical data processing ($p \leq 0.05$) (ANOVA) was calculated.

Results and Discussion

The consumption of whole grains, which are rich in dietary fiber, resistant starch, vitamins, minerals and micro constituents, was reported to have many physiological benefits related to "western diseases" such as coronary heart disease, colon cancer and diabetes. However, the whole grain foods have not been attractive to consumers because the higher bran and germ in whole grain flour reduced the quality and sensory value of the end-use products (Hung et al., 2007).

Dietary fiber

Over the last decades, consumer demands in the field of industrially food production have changed considerably. For this reason, foods today are not intended only to satisfy hunger and to provide necessary nutrients, but also to prevent nutrition-related diseases and enhance physical and mental well-being of consumers. In this regard, functional foods offer an outstanding opportunity to improve the quality of products. Early functional foods were characterised by fortification with vitamins. Subsequently, the focus has shifted to foods enriched with dietary fibre (Foschia et al., 2013).

In the present research significant differences ($p=0.007$) in total dietary fiber content of analysed flour samples were established (Table 1).

Table 1

Total dietary fiber, vitamin B_1 in B_2 content in flour samples

Flour sample	Dietary fiber, g 100 g^{-1}	Vitamin, mg kg^{-1}	
		B_1	B_2
Hull-less barley*	16.68±0.13	3.5±0.2	0.91±0.01
Rye*	16.71±0.12	4.2±0.1	1.28±0.02
Triticale*	12.80±0.14	3.6±0.2	1.01±0.02
Wheat*	11.66±0.11	4.8±0.1	1.28±0.04
Wheat 550 type	3.90±0.10	2.5±0.1	0.62±0.02

*whole grain flour

Higher dietary fiber content was found in whole grain hull-less barley and rye flour (Table 1); it was by approximately − 77% higher ($p=0.008$) comparing with wheat flour 550 type, by approximately − 23% higher ($p=0.001$) comparing with whole grain triticale flour and by approximately − 30% higher ($p=0.001$) comparing with whole grain wheat flour samples. However there are not found significant differences ($p=0.445$) in dietary fiber content in analysed whole grain hull-less barley and rye flour samples (Table 1).

According to the scientific literature, the total dietary fiber content of whole grain rye flour could be in the range from 18.7 to 22.2% (Andersson et al., 2009a), whole grain wheat flour – from 12.7 to 22.1% (Gebruers et al., 2008), whole grain triticale – from 13.2 to 16.0% (Rakha et al., 2011), hull-lessbarley – of 10.1 to 21.6% (Yalcin et al., 2007), what mainly corresponds to present results in this research.

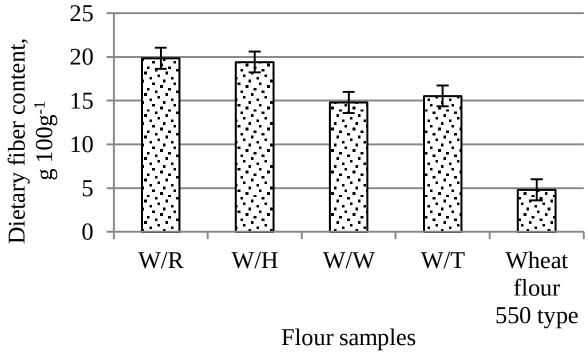

Figure 1. Total dietary fiber content of whole grain flour blends

W/R – 80% wheat flour 550 type and 20% whole rye flour; W/H – 80% wheat flour 550 type and 20% whole hull-less barley flour; W/W – 70% wheat flour 550 type and 30% whole wheat flour; W/T – 70% wheat flour 550 type and 30% whole triticale flour

As results of our experiments show, the lowest total dietary fiber contend was obtained in wheat flour 550 type (Figure 1, Table 1), what mainly could be explained with only grain middle part milling. Lower analysed parameter content, as 14.786±0.148 g 100 g^{-1} and 15.533±0.005 g 100 g^{-1} (Figure 1), was obtained for whole wheat and triticale flour blend. However, the higher total dietary fiber content, as 19.833±0.175 g 100 g^{-1} and 19.412±0.352 g 100 g^{-1} (Figure 1) was obtained in whole rye and hull-less barley flour blend.

Vitamins

B vitamins all function as coenzymes in the central pathways by which fat and carbohydrate are metabolized within the cell. The vitamins are concentrated in the aleurone layer of cereal seeds and milling and refining of cereals can lead to large losses (Sanders et al., 2003).

According to the literature, in the present research higher B_1 and B_2 vitamin content was obtained in whole grain flour (Table 1) comparing with wheat flour 550 type, because of milling of grain all parts including aleurone layer.

Similar vitamin B_1 and B_2 content was found in whole grain rye and wheat flour samples. However lower vitamins content was found in wheat flour type 550.

During mathematical data processing it was detected, that B_1 vitamin content in whole grain rye and wheat flour was significantly (p=0.114) higher than in hull-less barley and triticale – by 25%; and by 46% higher (p=0.744) comparing with wheat flour type 550. Similar results were detected during analysing of vitamin B_2 content in flour samples. As a result lowest vitamin B_2 content was obtained in wheat flour type 550; it was by 52% lower comparing with vitamin content in whole grain rye and wheat flour, by 32% lower comparing with whole grain hull-less barley flour and by 37% lower comparing with whole grain triticale flour. Obtained results mainly could be explained with grain individuality and vitamin forming intensity during grain growing.

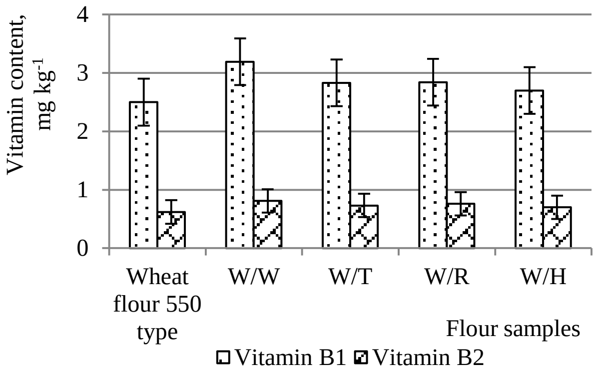

Figure 2. Vitamins content in whole grain flour blends

W/R – 80% wheat flour 550 type and 20% whole rye flour; W/H – 80% wheat flour 550 type and 20% whole hull-less barley flour; W/W – 70% wheat flour 550 type and 30% whole wheat flour; W/T – 70% wheat flour 550 type and 30% whole triticale flour

Lower B_1 vitamin content, as 2.7±0.14 mg kg^{-1} was obtained for blend with whole hull-less barley flour (W/H). However, the higher, as 3.19±0.28 mg kg^{-1}, was obtained for blend with whole wheat flour (W/W) (Figure 2). Differences mainly could be explained with grain individuality. In the scientific literature it is mentioned – grains are rich in thiamine, especially barley 0.356, mg 100 g^{-1} (Lebiedzinska et al., 2006). Lower B_2 vitamin content was obtained for flour blend with whole hull-less barley flour (W/H), whole rye (W/R) and whole triticale grain (W/T) flour. However, the higher B_2 vitamin content, as 0.81±0.28 mg kg^{-1} was obtained in flour blend with whole wheat flour (W/W) (Figure 2).

As a result it could be possible to increase the dietary fiber and B_1 and B_2 vitamins content in pasta by using of the whole-grain flour blends. Because in the scientific literature is mentioned, that, for example, wheat whole grain is a source of health-promoting phytochemicals in addition to traditional nutrients, including carbohydrates, proteins, lipids, vitamins, and minerals. Removal of wheat bran outer layers and wheat germ to produce semolina for pasta production significantly decreases phytochemicals and nutrients responsible for the health benefits of whole wheat grain. Whole wheat pasta is an ideal product for retention of the natural substances present in the durum wheat kernel. This chapter provides an overview of the relationship between whole grains and current health conditions, use of whole grain in pasta products, bioactive phytochemicals in whole grain and pasta, and, lastly, the major and minor nutrients in whole wheat pasta (Hirawan and Beta, 2014).

Conclusions

In the present research significant differences in total dietary fiber of analysed whole grain rye, hull-less barley, triticale and wheat flour samples were established. Higher dietary fiber content was found in whole grain hull-less barley and rye flour, lower − in whole wheat and triticale flour blend.

B_1 and B_2 vitamin content in whole grain rye and wheat flour was significantly higher than in hull-less barley and triticale. Lower B_1 vitamin content, as 2.7±0.14 mg kg^{-1} was obtained for hull-less barley flour blend, the higher as 3.19±0.28 mg kg^{-1} for wheat flour blend. Lower B_2 vitamin content was obtained for flour blends made with whole hull-less barley, triticale and rye flour, however, the higher B_2, as 0.81±0.28 mg kg^{-1} in blend with whole wheat flour.

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References

1. Anderson J.W., Baird P., Davis J.R.H., Ferreri S., Knudtson M., Koraym A. (2009a) Health benefits of dietary fiber. *Nutrition Reviews*, No. 67, p.188–205.
2. Andersson R., Fransson G., Tietjen M., Aman P. (2009b) Content and molecular-weight distribution of dietary fiber components in whole-grain rye flour and bread. *Agriculture and Food Chemistry*, Vol. 57, p. 2004–2008.
3. Batifloulier F., Verny M.A., Chanliaud E., Demigne C. (2006) Variability of B vitamin concentrations in wheat grain, milling fractions and bread products. European *Agronomy*, Vol.25, p. 163–169.
4. Brownlee I.A. (2011) The physiological roles of dietary fibre. *Food Hydrocolloids*, Vol. 25, p.238–250.
5. Doxastakis G., Zafiriadis I., Irakli M., Marlani H., Tananaki C. (2002) Lupin, soya and triticale addition to wheat flour doughs and their effect on rheological properties. *Food Chemistry*, Vol. 77, Iss. 2, p. 219–227.
6. Foschia M., Peressini D., Sensidoni A., Brennan C.-S. (2013) The effects of dietary fibre addition on the quality of common cereal products. *Cereal Science*, Vol. 58, Iss. 2, p. 216–227.
7. Franz M., Sampson L. (2006) Challenges in developing a whole grain database: definitions, methods, and quantification. *Food Composition and Analysis*, Vol. 19, p. 38–44.

8. Gaoshuang L., Chen H., Chen S., Tian J. (2012) Chemical composition and physicochemical properties of dietary fiber from *Polygonatum odoratum* as affected by different processing methods. *Food Research International,* Vol. 46, p. 406–410.
9. Gebruers K., Dornez E., Boros D., Fras A., Dynkowska W., Bedo Z. (2008) Variation in the content of dietary fiber and components thereof in wheat's in the health rain diversity screen. *Agriculture and Food Chemistry*, Vol. 56, p. 9740–9749.
10. Hägg M., Kumpulainen J. (1993) Thiamine and riboflavin contents in domestic and imported cereal products in Finland. *Food Composition and Analysis*, Vol. 6, Iss. 4, p. 299–306.
11. Heiniö R.-L., Liukkonen K.-H., Katina K., Myllymäki O., Poutanen K. (2003) Milling fractionation of rye produces different sensory profiles of both flour and bread. *LWT – Food Science and Technology*, Vol. 36, Iss. 6, p. 577–583.
12. Hirawan R., Beta T. (2014) *Whole wheat pasta and health.* **In**: Wheat and Rice in Disease Prevention and Health, Academic Press, p. 5−16.
13. Hung P.V., Maeda T., Morita N. (2007) Dough and bread qualities of flours with whole waxy wheat flour substitution. *Food Research International*, Vol. 40, Iss. 2, p.273−279.
14. Lang R., Jebb S.A. (2003) Who consumes whole grains, and how much? *Proceedings of the Nutrition Society*, Vol.62, p. 123–127.
15. Lebiedzinska A., Szefer P. (2006) Vitamins B in grain and cereal–grain food, soy-products and seeds. *Food Chemistry*, Vol. 95, p. 116–122.
16. Liu R.H. (2007) Whole grain phytochemicals and health. *Journal of Cereal Science*, Vol. 46, p. 207.
17. McKeown N.M., Meigs J.B., Liu S., Wilson P.W.F., Jacques P.F. (2002) Whole-grain intake is favourably associated with metabolic risk factors for type 2 diabetes and cardio vascular disease in the Framingham Offspring Study. *American Journal of Clinical Nutrition*, Vol. 76, p. 390–398.
18. Okarter N., Liu R.H. (2010) Health benefits of whole grain phytochemicals. *Food Science and Nutrition*, Vol. 50, p.193–208.
19. Rakha A., Aman P., Anderson R. (2011) Dietary fiber in triticale grain: variation in content, composition, and molecular weight distribution of extractable components. *Cereal Science*, Vol. 54, p. 324–331.
20. Sanders T., Emery P. (2003) *Molecular basis of human nutrition.* CRC Press, p. 94–96.
21. Sissons M.J., Ames N.P., Hare R.A., Clarke J.M. (2005) Relationship between glutenin subunit composition and gluten strength measurements in durum wheat. *Science of Food and Agriculture*, Vol. 85, p. 2445–2452.
22. Slavin J. (2003) Why whole grains are protective: biological mechanisms. *Proceedings of the Nutrition Society*, Vol. 62, p. 129.
23. Slavin J. (2004) Whole grains and human health. *Nutrition Research Reviews*, Vol. 17, p. 99–110.
24. Troccoli A., Borelli G.M., Vita De P., Fares C., Fronzo Di N. (2000) Durum wheat quality: a multidisciplinary concept. *Cereal Science*, Vol. 32, p. 99–113.
25. Wang L., Deng L., Wang Y., Zhang Y., Qian H., Zhang H., Qi X. (2014) Effect of whole wheat flour on the quality of traditional *Chinese Sachima*. *Food Chemistry*, Vol. 152, Iss. 1, p. 184–189.
26. Yalcin E., Celik S., Akar T., Savim H., Koksel H. (2007) Effects of genotype and environment on β-glucan and dietary fiber contents of hull-less barleys grown in Turkey. *Food Chemistry*, Vol. 101, p. 171–176.