EVALUATION OF NUTRITIONAL QUALITY OF RAW AND ROASTED BUCKWHEAT (*FAGOPYRUM ESCULENTUM* M.) FLUOR

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Abstract

Buckwheat is a gluten-free pseudocereal which is abundant in nutrients, like proteins, amino acids, dietary fibre, minerals, vitamins, phenolics and flavonoids. The amino acid content, dietary fibre, Fe, Zn, vitamins B_1 and B_2, total phenolic content, rutin and quercetin were analysed in the flour of raw and roasted buckwheat in order to evaluate their nutritional quality and possible differences. It was concluded that there are relatively small differences in dietary fibre content, Fe, Zn, vitamins B_1 and B_2, and quercetin between raw and roasted buckwheat flour. However, raw buckwheat flour showed significantly ($p<0.05$) higher total phenolic, rutin and some essential amino acid content, like valine, leucine, phenylalanine, histidine, and lysine, compared to roasted buckwheat flour. Both buckwheat flour types could be used as ingredients with high nutritional value in the production of new functional products.

Key words: *buckwheat, amino acids, dietary fibre, bioactive compounds*

1. INTRODUCTION

Buckwheat is a gluten-free pseudocereal which has potential as functional food due to the biological value (Krumina-Zemture et al. 2016; Wronkowska et al. 2015; Christa &Soral-Śmietana 2008; Bonafaccia et al. 2003b; Ikeda 2002). Furthermore Préstamo et al. (2003) reported that buckwheat is a prebiotic and healthy food due to the increase of lactic acid bacteria and bifidobacteria in the rat intestine, when rats were fed with buckwheat diet.

Buckwheat is a good source of non-gluten protein with high biological value (Biel &Maciorowski 2013; Kato et al. 2001), relatively low digestibility (Liu et al. 2001), but with the highest amino acid scores of protein in plant foodstuffs (Qin et al. 2010). The results of research by Tomotake et al. (2000) showed that buckwheat protein was more effective in suppression of gallstone formation than soy protein isolates while Liu et al. (2001) reported that buckwheat protein can promote the suppression of 1,2-dimethylohydrazine-induced colon carcinogenesis in rats. Buckwheat is a substantial food product that contains a well-balanced amino acid composition with high amount of lysine – limited amino acid in wheat (Gonçalves et al. 2016), whereas methionine and threonine content in buckwheat proteins are low (Christa &Soral-Śmietana 2008).

The favourable effects of buckwheat *in vivo* are associated especially with its carbohydrates and fibre components (Rokka et al. 2013). Steadman et al. (2001) indicated that the whole grain buckwheat contained 7% of total dietary fibre, while bran with hull fragments had 40% of total dietary fibre. It confirmed the conclusions of Biel &Maciorowski (2013) that groat, bran and hull had a significantly different level of dietary fibre fractions. However, buckwheat fibre can reduce overweight related risk factors of cardiovascular diseases in rats (Son et al. 2008).

Buckwheat is a good source of micro-elements, like iron, zinc, cooper, manganese (Mota et al. 2016; Ikeda et al. 2005), and of B group vitamins, like thiamine, riboflavin and pyridoxine (Bonafaccia et al. 2003b). Iron-deficiency anaemia composes the most widely prevalent nutritional problem in the world (Hemalatha et al. 2007). However, it is known that bioavailability of micro-elements, like iron and zinc, is low in plant foodstuffs (Sandberg 2002). While Ikeda et al. (2005) reported that the enzymatic digestion of buckwheat groats enabled the large proportion of zinc, copper and potassium to be released as soluble forms, which means that these three minerals in buckwheat may be available for intestinal absorption.

Buckwheat is associated with the antioxidant properties due to the phenolic compounds. Rutin and quercetin with their antioxidative activity compose the major group of polyphenols in buckwheat (Holasova et al. 2002). Furthermore both polyphenols can favourably influence the treatment of chronic venous insufficiency / peripheral vascular disease (Erlund et al. 2000). Cai et al. (2004) indicated that they demonstrated antioxidant, antimicrobial and anti-inflammatory activities.

It is known that roasting affects the chemical composition and functional properties of buckwheat (Zielińska et al. 2007). Therefore, the aim of this research was to evaluate and compare the nutritional value, which included amino acid content, dietary fibre, Fe, Zn, vitamins B_1 and B_2, total phenolic content, rutin and quercetin, of raw and roasted buckwheat flour.

2. MATERIALS AND METHODS

2.1. Buckwheat samples

Two types of buckwheat (*Fagopyrum esculentum*) flour: raw (raw-BF) and roasted (roasted-BF), grown in Saldus, Latvia in 2015 (Farm 'Bebri') were used.

2.2. Determination of moisture content

Moisture content of buckwheat flour was determined according to the method of LVS EN ISO 712:2010 A. The measurements were performed four times.

2.3. Determination of amino acid content

The amino acid content in buckwheat flour was determined with amino acid analyser '*Microtechna Praha AAA339*' according to the requirements of 'Amino acid standard solution for protein hydrolysates – 0.5 μmoles mL^{-1}'. The measurements were performed in triplicate.

2.4. Determination of the total dietary fibre content

The total dietary fibre content of buckwheat flour was analysed using the equipment '*Fibertec system 1010 Heat Extractor*' according to the Official Method 985.29 'Total dietary fibre in Foods'. The measurements were performed in triplicate.

2.5. Determination of microelements

Buckwheat flour samples were dry-ashed in concentrated HNO_3 vapour and re-dissolved in 3% HCl for Fe and Zn detection. Fe and Zn contents were measured by atomic absorption spectrophotometry (AAS) AAnalyst 700 (Perkin-Elmer, Singapore) and acetylene-air flame (Page et al. 1982).

2.6. Determination of vitamins B_1 and B_2

Vitamin B_1 concentration in buckwheat flour was measured by AOAC Official Method 986.27, vitamin B_2 – by AOAC Official Method 970.65.

2.7. Determination of total phenolic content (TPC)

The total phenolic content of the buckwheat extracts was determined applying the Folin-Ciocalteu spectrophotometric method (Singleton et al. 1999) with some modifications. To 0.5 ml of extract 2.5 ml of Folin–Ciocalteu reagent (diluted 10 times with water) was added and after 3 minutes 2 ml of sodium carbonate (Na_2CO_3) (75 g L^{-1}) was added. The sample was mixed. The control sample contained all the reaction reagents except the extract. After 2 h of incubation at room temperature, the absorbance was measured at 765 nm. Total phenolic content was expressed as gallic acid equivalent (GAE) 100 g^{-1} dry weight (DW) of the raw and roasted buckwheat flour.

2.8. Rutin and quercetin analysis

Rutin and quercetin content in buckwheat flour was analysed by Shimadzu HPLC system LC–20 Prominence including Photo-diode Array detector SPD-M20A, Solvent Delivery Unit LC-20AD, Column Oven CTO-20A, AutosamplerSIL-20A, System Controller CBM-20A and data system LCsolution software.

2.9. Statistical analysis

The results were analysed using the analysis of variance. T-test was applied to compare the mean values; p-value at 0.05 was used to establish the significant differences.

3. RESULTS AND DISCUSSION

Protein content in the flour of common buckwheat cultivars ranged from 8.06 to 12.44%, in average 10.32% (Qin et al. 2010); however more important attention is given to composition and content of amino acids (Table 1), which determine the nutritional value of proteins.

Table 1. Amino acid content of raw and roasted buckwheat flour, mg 100 g^{-1} [a]

Amino acids	Raw-BF	Roasted-BF
Aspartic acid	1.31	1.12
Threonine*	0.34	0.30
Serine	0.53	0.42
Glutamic acid	2.43	1.99
Prolamin	0.20	0.30
Glycine	0.68	0.50
Alanine	0.66	0.32
Valine*	0.42	0.22
Methionine*	0.16	0.12
Isoleucine*	0.14	0.14
Leucine*	0.66	0.44
Tyrosine*	0.36	0.31
Phenylalanine*	0.52	0.35
Histidine*	0.64	0.35
Lysine*	0.68	0.58
Arginine	0.72	0.57
Tryptophan	0.16	0.18

[a] Mean values of triplicate determinations; * Essential amino acids

In general amino acid content in raw buckwheat flour was higher than in roasted buckwheat flour except prolamin, tryptophan and isoleucine. Aspartic acid and glutamic acid among the all amino acids were abundant in raw and roasted buckwheat flour. Evaluating essential amino acid content, raw buckwheat flour had significantly higher content of valine, leucine, phenylalanine, histidine, and lysine ($p<0.05$) compared to roasted buckwheat flour. Therefore the sum of essential amino acids in raw buckwheat flour (3.92 mg 100 g^{-1}) was higher than in roasted buckwheat flour (2.81mg 100 g^{-1}). In literature it is reported that buckwheat is characterized by high lysine content, amounting to about 6 mg 100 g^{-1} of proteins (Bonafaccia et al. 2003b). By recalculation of lysine content in 100 g of protein, research data confirmed the conclusions of literature about lysine. Raw buckwheat flour showed low lysine/arginine and low methionine/arginine ratio which allows suggesting that according to literature raw buckwheat

flour could have blood cholesterol lowering properties (Biel &Maciorowski 2013), while roasted buckwheat flour had only low methionine/arginine ratio. Research data showed that raw buckwheat flour is a good source of essential amino acids in nutrition and that the roasting of buckwheat groats affects the amino acid content. Similar conclusions about roasting effect on the chemical composition of buckwheat were reported by Zielińska et al. (2007).

Important indicators for assessing nutritional value of pseudocereals are dietary fibre, minerals and B-group vitamin content, which are given in Table 2.

Table 2. Dietary fibre and micronutrient content of raw and roasted buckwheat flour

Samples	**Moisture, %**	**Dietary fibre, g 100 g^{-1}DW**	**Fe,**	**Zn,**	**Vitamin B_1**	**Vitamin B_2**
			mg kg^{-1} DW		**mg 100 g^{-1}DW**	
Raw-BF	13.60±0.95	17.33±0.01	32.41±0.12	27.78±0.19	1.22±0.05	1.34±0.03
Roasted-BF	11.76±0.76	17.27±0.03	31.73±0.09	27.20±0.07	1.58±0.06	1.53±0.07

The total dietary fibre content of raw and roasted buckwheat flour was high and equal. Results are higher than those reported by Bonafaccia et al. (2003b), where total dietary fibre content in common buckwheat flour was 6.77 % DW and in tartary buckwheat flour – 6.29 % DW, but similar to the results reported by Hęś et al. (2014) on raw buckwheat groats.

According to European Food Safety Authority (EFSA) recommendations, where daily dietary fibre intake for adults is reported 25 g, 100 g of raw and roasted buckwheat flour can provide 59.88% and 60.96% of recommended daily dietary fibre intake.

Evaluating iron and zinc concentration in raw and roasted buckwheat flour, it was concluded that results for both buckwheat flour types were similar and that the roasting of buckwheat groats did not affect the iron and zinc content. In addition, raw and roasted buckwheat flour was rich in iron and zinc. Results reported by Mota et al. (2016) were close for iron, but lower for zinc content in raw buckwheat while results by Bonafaccia et al. (2003a) showed higher iron content (82.7 mg kg^{-1} DW) and lower zinc content (20.1 mg kg^{-1} DW) for common buckwheat flour.

The present results indicated that 100 g of raw and roasted buckwheat flour contain about 28% of iron for males, 16% for females and about 17% of zinc for adults of recommended dietary intake in Latvia (established by Ministry of Health of Latvia in 2008).

Different results were obtained for vitamins B_1 and B_2 in buckwheat flour. Roasted buckwheat flour had higher vitamin content compared to raw buckwheat flour. However, the differences were relatively small and insignificant ($p>0.05$). Content of vitamins B_1 and B_2 in raw and roasted buckwheat flour can provide significant amount of recommended dietary intake of vitamins for inhabitants of Latvia. Therefore it could be concluded that buckwheat flour is an excellent source of vitamins B_1 and B_2 in nutrition.

In literature buckwheat is characterised as functional food with antioxidant and anti-inflammatory properties (Zhang et al. 2012), where the antioxidant potential of buckwheat is determined mainly by phenolic compounds (Holasova et al. 2002). Rutin, quercetin and total phenolic content in raw and roasted buckwheat flour are given in Table 3.

Total phenolic content showed significant differences between raw and roasted buckwheat flour ($p<0.05$). Raw buckwheat flour had two times higher total phenolic content compared to roasted buckwheat flour which indicated that roasting of buckwheat groats significantly affects the phenolic content. This conclusion was in conformity with literature (Zhang et al. 2010; Wronkowska et al. 2015)

that roasting, pressured-steam heating and microwave heating of buckwheat flour caused a decrease in total phenolics, total flavonoids and antioxidative activities.

Table 3. Rutin, quercetin and total phenolic content in raw and roasted buckwheat flour

Samples	**TPC,**	**Rutin**	**Quercetin**
	mg GAE 100 g^{-1} DW	**mg 100 g^{-1} DW**	
Raw-BF	974.74	0.99	0.020
Roasted-BF	453.68	0.36	0.019

Rutin is the main buckwheat polyphenol with antioxidant, anti-inflammatory and anti-carcinogenic properties (Wronkowska et al. 2015). However the content of rutin in buckwheat flour samples of this research was lower compared to literature data (Kreft et al. 2006; Kiprovski et al. 2015). This could be connected with different factors; Guo et al. (2011) indicated that polyphenol content of buckwheat depends on variety, location and environmental conditions. Analysing rutin content in raw and roasted buckwheat flour, there was determined significant difference: raw buckwheat flour had nearly three times higher rutin content than roasted buckwheat flour. A similar conclusion was reported by Wronkowska et al. (2015) that raw buckwheat groats were almost two times richer in phenolic compounds than roasted groats. This could be explained by hydro-thermal processes used for roasting where temperature and heating time adversely affect rutin content in buckwheat groats (Dietrich-Szostak&Oleszek 1999).

Quercetin content in buckwheat flour samples was low, but it was possible to find similar conclusions in literature, where Qin et al. (2010) reported that quercetin content in most common buckwheat cultivars was not detected except some cultivars with quercetin amount of 0.05 mg g^{-1}and 0.09 mg g^{-1}. Furthermore there were not determined differences in quercetin content between raw and roasted buckwheat flour.

4. CONCLUSIONS

Raw buckwheat flour showed significantly higher content of total phenolics, rutin and essential amino acids, like valine, leucine, phenylalanine, histidine, and lysine ($p<0.05$). Roasting did not affect the total dietary fibre, iron, zinc, vitamins B_1 and B_2, and quercetin content in buckwheat flour. Both buckwheat flour types could be used as ingredients with high nutritional value in the production of new functional products.

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