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Nutrient Evaluation of Different Buckwheat Genetic Resources

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Abstract

Common buckwheat (*Fagopyrum esculentum* Moench) and tartary buckwheat (*Fagopyrum tataricum* Gaerth.) are underutilized pseudo-cereals and both considered nutritional food. Eight common and eleven tartary buckwheat accessions acquired from Slovenian plant gene bank were grown at the experimental fields of the Agricultural Institute of Slovenia in 2014. Dried grains were homogenised and analysed for several nutrient parameters: moisture content (11–14% dry weight, DW), total proteins (11–16 % DW), dietary fibre (15–19 % DW), ash (2–6 % DW) and total fats (1.8–2.6 % DW). The fatty acids (C14:0, C16:0, C18:0, C18:1n9, C18:2n6, C18:3n3, C20:0) were determined using gas chromatography, free amino acids (*Gly, Glu, Arg, Lys, Asp, Ser, Phe, Ala, Val, Thr, Pro, Ile, Met, His, Cys, Leu, Tyr*) by the high-performance liquid chromatography and multi-mineral analysis (K, P, Si, S, Ca, Fe, Cl, Ti, Zn) using X-ray fluorescence spectroscopy. The results show significant differences between two buckwheat species, and their gene bank accessions for investigated nutritional parameters.

Key words: buckwheat, amino acid, dietary fibre, fatty acid, minerals, proteins

Introduction

Buckwheat has played an important role in diets around the world over the last 8000 years, mainly in Eastern Europe and Asia (Rana et al. 2016). The genus *Fagopyrum* (family Polygonaceae) includes several different species, among which common buckwheat (*Fagopyrum esculentum* Möench) and tartary buckwheat (*Fagopyrum tartaricum* L. Gaerth) are cultivated and used for food worldwide.

Common and tartary buckwheat are short-season crop species, requiring only moderate soil fertility and 10 to 12 weeks to mature. Both species are considered important functional food crops, containing several important nutritional constituents in many countries around the world. Consumption of food from common and tartary buckwheat, as part of an everyday diet, has increased over the past few years due to the number of health-beneficial properties (Bonafaccia et al., 2003). It is well established that both buckwheat types represent a rich source of high quality proteins, with a balanced amino acid composition, dietary fibre, retrograded starch, high quality lipids, vitamins, essential minerals and antioxidants, including phenolic compounds (Pongrac et al., 2010). Additionally, both buckwheat species are gluten-free, and thus provide an important alternative nutritious food for people with celiac disease (Giménez-Bastida et al., 2015).

The aim of the present study was to determine the composition of several nutrients (total proteins, dietary fibre, ash and total fats), fatty acids composition and multi-mineral content of common and tartary buckwheat from Slovenian plant gene bank collection.

Material and Methods

Eight common (*Fagopyrum esculentum* Moench) and eleven tartary buckwheat (*Fagopyrum tartaricum* L. Gaerth) accessions provided from Slovenian plant gene bank were grown as a main crop in the experimental field of the Infrastructure Centre Jablje, Agricultural Institute of Slovenia, Slovenia (304 m above sea level; 46.151°N 14.562°E). The mature grains were harvested in September 2014. The dried grains, containing on average 12.8 % and 11.5 % of moisture for common and tartary buckwheat respectively, were milled using a laboratory mill (Retsch ZM 200) and further homogenised using ball mill (Retsch MM 400).

Moisture content was determined by heating the samples to 103°C for 4 hours (EC 152/2009 App. III A).

Total proteins were analysed using method ISO 5983:2, using factor 6,25; modified method ISO 6865 using FiberCap was used for the determination of dietary fibre, for ash ISO 5984 was used, and total fats were analysed with petroleum ether extraction (152/2009 App. III H). Fatty acid composition was determined using gas chromatography of fatty acid methyl esters (FAMEs). NaOH and BF_3 in methanol were used for transesterification and heptadecanoic acid as internal standard for quantification of fatty acids. Identification of fatty acids was carried out using a reference standard mixture of methyl esters of higher fatty acids (Lipid standard Sigma 189-19). The multi-element analysis was performed non-destructively using energy dispersive X-ray fluorescence (EDXRF) spectroscopy. Pellets made from 0.5 g to 1.0 g of powdered sample material were analysed using an EDXRF spectrometer composed of a Si (Li) detector, a spectroscopy amplifier, an analog to digital converter and a PC-based multichannel analyser (Canberra). The analysis of complex X-ray spectra was performed using the AXIL (Nečemer et al., 2008) spectral analysis program. Quantification was performed using the in-house developed QAES (Quantitative Analysis of Environmental Samples) software (Nečemer et al., 2011). The estimated uncertainty of the analysis was 5 % to 10 %. The content of free amino acids was determined according to ISO 13903 (ISO 13903, 2005) adapted for plant materials. Amino acids were determined in oxidized samples and hydrolyzated with 6M HCl in the presence of phenol. The dry residue was dissolved in dilute HCl and derivatized with N-aminoquinolyl succinate. High-performance liquid chromatography (HPLC) coupled with fluorescence detector (FLD) have been used for the analyses.

Results and Discussion

The average content of total proteins, dietary fibre, ash and total fats in grains of common and tartary buckwheat species is presented in Fig. 1. All results are calculated as % of dry weight (DW). The average total protein content was 14.1 % DW for common and 12.2 % DW for tartary buckwheat grains and the average dietary fibre content 16.6 % DW for common and 18.1 % DW for tartary buckwheat grains. Common buckwheat grains contained more proteins (+1.9%) and less dietary fibre (–1.5%) compared to tartary buckwheat. Ash content was on average 1 % higher for tartary buckwheat grains. Grains of tartary buckwheat contained on average 0.2 % more total fats compared to common buckwheat. Previous reports on chemical composition of buckwheat grains showed similar protein content, and somewhat higher dietary fibre and fat content (Bonafaccia et al., 2003; Eggum et al., 1980).

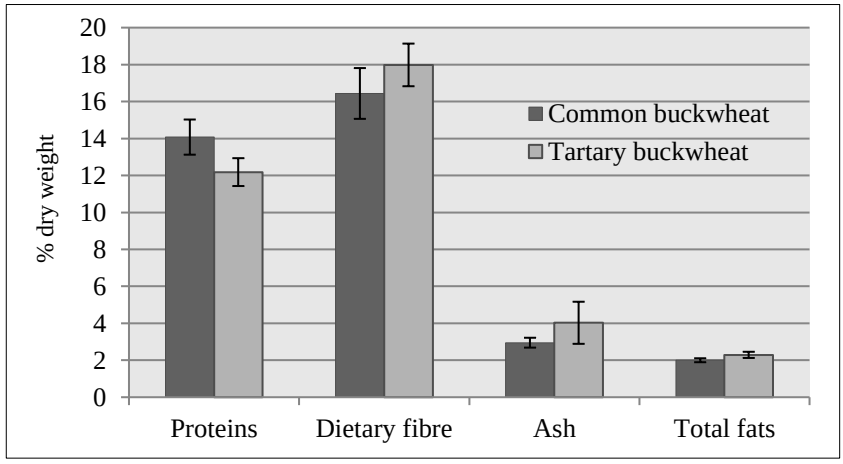

Fig. 1. Total proteins, dietary fibre, ash and fats (% DW) in grains of common and tartary buckwheat
Укупни протеини, дијеталнa влакна, пепео и масти (% суве масе) у зрнима обичне хељде и татарске хељде

The fatty acid analysis with gas chromatography revealed the presence of the following seven fatty acids in buckwheat species: saturated myristic (C14:0), palmitic (C16:0), stearic (C18:0) and arachidic (C20:0); and unsaturated oleic (C18:1n9), linoleic (C18:2n6) and α-linolenic (C18:3n3). Fatty acids content and total amount of all fatty acids in common and tartary buckwheat grains is reported in Tab. 1. Fatty acids content is expressed as the mass ratio of all of the fatty acids analysed and total fatty acid content as mg/100 g fresh weight (FW).

Prevailing fatty acid in both buckwheat species was linoleic acid (40.7 %), followed by the oleic (35.6 %), palmitic (16.1 %), α-linolenic (3.2 %), arachidic (2.3 %), stearic (1.9 %) and myristic acid (0.3 %). The total fatty acid content varied considerably, from 200 to 316 mg/100 g FW. The data showed differences between two buckwheat species and representing gene bank accessions for fatty acid profiles and total fatty acids content (Tab. 1). Bonafaccia et al. (2003) found comparable results on fatty acids distribution to ours on one common and one tartary buckwheat cultivar. Gulpinar et al. (2012) reported lower contents of palmitic and linoleic acid in their study on common buckwheat variety.

Mineral concentrations of common and tartary buckwheat grains are expressed as mg/kg DW and presented in Tab. 2. Nine different minerals were monitored in this study and can be divided into two groups: the macro-minerals (>1 g/kg DW) of K, P, Si, S, and Ca, and the micro-minerals (>1 mg/kg DW) of Fe, Cl, Ti, and Zn.

Tab. 1. Fatty acid composition of common and tartary buckwheat grains
Састав масних киселина у зрнима обичне хељде и татарске хељде

Fatty acid *масна киселина* buckwheat *хељда*	wt. %							mg/100 g FW
	C14:0	C16:0	C18:0	C18:1n9	C18:2n6	C18:3n3	C20:0	total fatty acids *укупне масне киселине*
CB1	0.4	15.6	1.9	37.4	40.1	2.7	1.9	237.0
CB2	0.3	15.8	1.9	36.6	40.6	2.9	1.9	226.7
CB3	0.2	13.5	1.8	39.6	39.9	2.8	2.1	254.9
CB4	0.2	15.6	2.0	37.7	39.7	2.7	2.1	252.0
CB5	0.2	16.0	2.2	36.0	40.9	2.7	1.8	315.6
CB6	0.3	15.5	1.8	37.7	39.9	2.8	2.0	267.5
CB7	0.3	16.2	1.9	35.8	40.9	2.9	1.9	238.3
CB8	0.3	15.9	1.9	35.7	41.5	3.0	1.8	230.8
TB1	0.3	15.6	1.9	36.5	41.0	2.9	1.9	238.3
TB2	0.3	15.4	1.9	37.4	40.3	2.8	1.9	211.2
TB3	0.2	15.6	1.8	36.0	41.6	2.8	1.9	221.1
TB4	0.3	16.8	1.8	34.2	39.9	4.0	3.0	262.1
TB5	0.3	16.8	1.7	34.5	40.5	3.5	2.7	255.9
TB6	0.2	15.5	1.8	34.9	41.3	3.1	3.1	264.1
TB7	0.4	17.6	1.9	32.7	41.5	2.9	2.9	200.4
TB8	0.2	16.3	1.8	34.0	41.3	3.5	2.8	266.1
TB9	0.4	17.4	2.1	33.0	40.1	4.4	2.5	246.3
TB10	0.3	17.0	1.8	33.4	40.7	3.8	3.0	262.9
TB11	0.3	17.2	2.0	33.0	40.9	3.9	2.8	254.1

CB, common buckwheat (обична хељда)*; TB, tartary buckwheat* (татарска хељда)*; FW, fresh weight* (маса свјежих зрна).

The highest levels among these minerals were measured for K (4560–6570 mg/kg DW), P (3410–4850 mg/kg DW), Si (675–10400 mg/kg DW), which varied the most among all minerals, and S (753–1620 mg/kg DW). The less abundant minerals were Ca (an average content 744 mg/kg DW), Fe (an average content 301 mg/kg DW), Cl (an average content 111 mg/kg DW), Ti (an average content 48 mg/kg DW) and Zn (an average content 20 mg/kg DW).

Common buckwheat grains contained more S, Ca and Cl, and less K, P, Si, Fe and Ti compared to tartary buckwheat. The content of Zn was similar for both buckwheat species. Mota et al. (2016) reported much lower content of minerals Fe (29 mg/kg DW) and Ca (180 mg/kg DW) in common buckwheat compared to our results.

Tab. 2. Mineral content of common and tartary buckwheat grains

Минерални садржај у зрнима обичне хељде и татарске хељде

Mineral *минерал* / buckwheat *хељда*	mg/kg DW *(mg/kg суве масе)*								
	K	P	Si	S	Ca	Fe	Cl	Ti	Zn
CB1	5850	4850	2720	1600	676	184	128	23.6	21.5
CB2	6200	4310	1850	1380	481	167	113	17.6	20.1
CB3	5210	4050	686	1270	694	86	122	3.5	19.9
CB4	5790	4320	1920	1290	1140	196	201	23.9	19.2
CB5	5400	3990	942	1270	855	102	133	11.8	16.8
CB6	4560	4120	1390	1620	1150	136	145	10.5	19.9
CB7	5410	3410	675	998	853	118	158	6.7	18.9
CB8	4960	3440	2690	1120	1040	162	109	22.0	24.4
TB1	5630	4110	8740	1080	617	755	75	136.0	22.3
TB2	6570	4350	3570	1050	536	266	108	52.2	16.6
TB3	5810	4660	3320	1050	664	382	121	40.5	19.1
TB4	5820	4740	3980	1190	682	351	66	54.7	16.3
TB5	4960	4230	2550	1290	1020	227	70	31.4	24.4
TB6	5510	4100	881	987	633	91	91	4.6	18.7
TB7	5370	3990	1590	883	561	159	86	20.7	18.4
TB8	5710	4380	3380	1070	622	307	101	57.3	18.9
TB9	5870	3810	10400	1120	651	696	129	145.0	17.6
TB10	6390	3750	9580	753	678	827	89	133.0	19.2
TB11	5440	4050	6540	965	577	505	58	109.0	19.4

CB, common buckwheat (обична хељда)*; TB, tartary buckwheat* (татарска хељда)*; FW, fresh weight* (маса свјежих зрна).

Amino acid composition in common and tartary buckwheat grains is presented in Fig. 2. The following 17 free amino acids were identified and quantified: aspartic acid (*Asp*), threonine (*Thr*), serine (*Ser*), glutamic acid (*Glu*), proline (*Pro*), glycine (*Gly*), alanine (*Ala*), cysteine (*Cys*), valine (*Val*), methionine (*Met*), isoleucine (*Ile*), leucine (*Leu*), tyrosine (*Tyr*), phenylalanine (*Phe*), lysine (*Lys*), histidine (*His*) and arginine (*Arg*).

These amino acids can be divided into two groups: the essential amino acids of *Ile*, *Leu*, *Val*, *Phe*, *His*, *Lys*, *Thr* and *Met*, and non-essential amino acids of *Ala*, *Gly*, *Pro*, *Tyr*, *Asp*, *Glu*, *Arg*, *Ser* and *Cys*. The highest content in common buckwheat grains was shown for *Glu* (> 14 % of total proteins), followed by *Arg* (> 8 % of total proteins) and *Gly* (> 7 % of total proteins). In tartary buckwheat the most abundant was *Glu* (> 10 % of total proteins), followed by *Arg* (> 8 % of total proteins) and *Ser* (> 7 % of total proteins). Bonafaccia et al. (2003) reported similar amino acid profiles to ours on common and tartary buckwheat bran and flour.

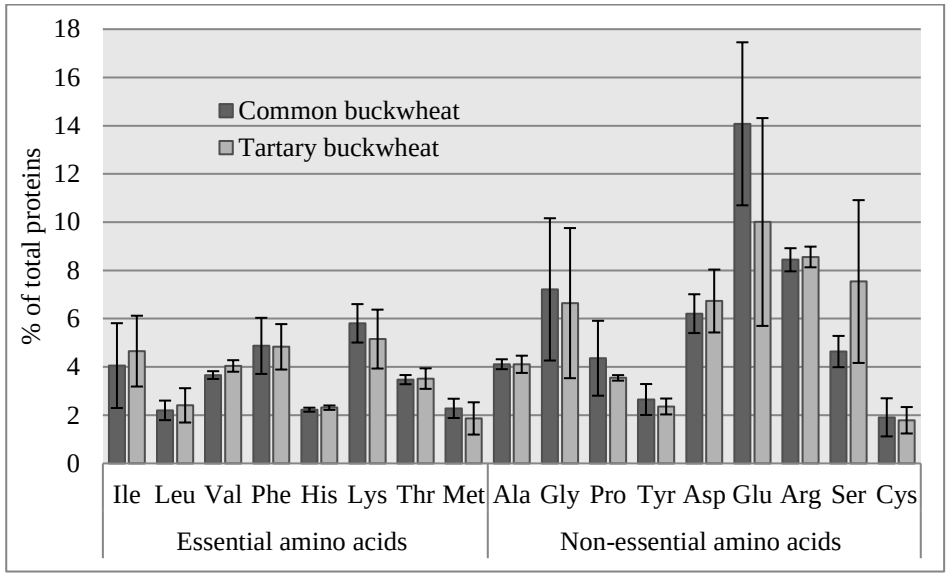

Fig. 2. Amino acid composition of common and tartary buckwheat grains
Садржај амино киселина у зрнима обичне хељде и татарске хељде

Conclusion

The focus of this paper was a quantitative determination of several nutrients in grains of different accessions of common and tartary buckwheat, which are typically consumed in Slovenia. There is still little information available on nutritive composition of different *Fagopyrum* spp. and their genetic resources.

Obtained data on the content of different nutritional parameters for analysed buckwheat species can be the basis for proposition that buckwheat should be introduced in our daily diet, in order to overcome various health problems. These data can also represent the basis for breeding cultivars with a higher nutritional quality.

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Вриједновање нутријената у различитим генетичким ресурсима хељде

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Сажетак

Хељда (*Fagopyrum esculentum* Moench) и татарска хељда (*Fagopyrum tataricum* Gaerth.) су недовољно искориштене псеудо-житарице, а могу се сматрају квалитетном храном. Осам принова хељде и једанаест принова татарске хељде добијених из Словенске банке биљних гена, засијано је на огледним пољима Пољопривредног института Словеније у 2014 години. Осушена зрна су хомогенизована и анализирана на неколико параметара: садржај влаге (11–14% суве материје, СМ), укупни протеини (11–16% СМ), дијетална влакна (15–19% СМ), пепео (2–6% СМ) и укупне масти (1.8–2.6% СМ). Профили масних киселина (C14:0, C16:0, C18:0, C18:1n9, C18:2n6, C18:3n3, C20:0) одређени су уз помоћ гасне кроматографије, просте аминокиселине (*Gly, Glu, Arg, Lys, Asp, Ser, Phe, Ala, Val, Thr, Pro, Ile, Met, His, Cys, Leu, Tyr*) течном хроматографијом високог притиска, а анализа већег броја минерала (K, P, Si, S, Ca, Fe, Cl, Ti, Zn, Rb, Sr, Br) помоћу рендгенске флуоресцентне спектроскопије. Резултати показују значајне разлике између двије врсте хељде и њихових принова у банци гена, у погледу испитиваних нутритивних параметара.

Кључне ријечи: хељда, аминокиселине, дијетална влакна, масне киселине, минерали, протеини

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