ELSEVIER

Food Chemistry 83 (2003) 1–5

Food Chemistry

www.elsevier.com/locate/foodchem

Trace elements in flour and bran from common and tartary buckwheat

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Received 5 February 2003; received in revised form 6 May 2003; accepted 6 May 2003

Abstract

The contents of Se, Cr, Rb, Zn, Fe, Co, Sb, Ba, Ni, Ag, Hg and Sn were analysed in the flour and bran of common and tartary buckwheat, obtained by milling in a stone mill. In both species most trace elements are concentrated mainly in the bran. However, there are relatively small differences in the contents of iron, antimony, and chromium between flour (extraction rate 55%) and bran fractions. In tartary buckwheat fine flour (extraction rate 42%) there is a lower trace element content than in normal flour. The potential use of buckwheat bran as a dietary source of Zn, and Se, is indicated.

Keywords: Common buckwheat; Tartary buckwheat; Trace elements; Selenium; Zinc

1. Introduction

Two buckwheat species are used for food: common buckwheat (*Fagopyrum esculentum*) and tartary buckwheat (*Fagopyrum tataricum*), the latter being grown in more harsh climatic conditions (Bonafaccia, Marocchini, & Kreft, 2003; Lin, Tao, & Li, 1992).

In Slovenia, and in other central European countries, buckwheat has been grown for centuries and is now, alongside spelt wheat (Bonafaccia et al., 2000), one of the most important alternative crops. It is suitable for ecological growing without the use of chemicals, following sustainable agricultural practice by developing and extending environmentally conscious technologies (Kreft, 1989; Vadnal, 2002; Vadnal & Bratusa, 2000). Buckwheat may be used for flour and groats products (Kreft, 1994). Buckwheat pasta and other buckwheat flour products are traditionally popular in Italy, Slovenia and in Asian countries (Kreft & Skrabanja, 2002). Other foods obtained from buckwheat are buckwheat floral honey (Nagai, Sakai, Inoue, Inoue, & Suzuki, 2001; Paradkar & Irudayaraj, 2002), green buckwheat tea, buckwheat sprouts, and fresh green plant parts used as a vegetable (Kreft, 1995; Park et al., 2000).

Buckwheat is safe for patients with coeliac disease (Skerritt, 1986), but it may contain some antinutritional factors—oversensitivity reactions may be caused in a very few people by ingesting buckwheat and its products or by exposure to buckwheat dust (Wieslander & Norbäck, 2001).

Buckwheat products are known as a dietary source of polyphenols (Kreft, Bonafaccia, & Zigo, 1994; Kreft, Knapp, & Kreft, 1999; Kreft, Skrabanja, Ikeda, Ikeda, & Bonafaccia, 1996; Nagai et al., 2001; Park et al., 2000; Watanabe, 1998), dietary fibre and resistant starch (Skrabanja, Laerke, & Kreft, 1998; Skrabanja, Liljeberg, Kreft, & Björck, 2001) and proteins with high biological value but relatively low true digestibility (Ikeda & Kishida, 1993; Skrabanja, Nygaard, & Kreft, 2000). In experimental animals, buckwheat proteins suppress gallstone formation better than soy protein isolate (Tomotake, 2000). They are connected with retardation of mammary carcinogenesis by lowering serum estradiol, and with suppression of colon carcinogenesis by reducing cell proliferation (Kayashita, Shimaoka, Nakajoh, Kishida, & Kato, 1999; Liu et al., 2001).

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0308-8146/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0308-8146(03)00228-0

Common buckwheat is grown in Slovenia and in the Alpine region of Italy (Valtellina and Val Venosta), and is used for many traditional regional food products. Tartary buckwheat was cultivated to some extent in Slovenia and Italy for centuries, but this ceased before the end of the 20th century. The cross border region Islek—which includes northern Luxemburg, the Westeifel (Germany) and the border area of the German-speaking part of Belgium—is at present the only place in Europe where tartary buckwheat is still grown, on approximately 50 ha, for human food. The University of Ljubljana, Slovenia, has carried out a pluriannual research project for the Luxemburgish Ministry of Agriculture, in order to further develop the cultivation and utilization of tartary buckwheat.

A few studies have been reported on the contents of zinc, copper, manganese, boron, aluminium, nickel, molybdenum, cobalt, cadmium, chromium, iron and lead in common buckwheat (Ikeda, Edotani, & Naito 1990; Ikeda & Yamashita, 1994; Ikeda, Yamashita, & Kreft, 2000; Steadman, Burgoon, Lewis, Edwardson, & Obendorf, 2001), but there is little information about the content of other trace elements in common buckwheat. In tartary buckwheat, of the trace elements, only zinc contents was studied (Ikeda & Yamaguchi, 1993). The present work is, as far as we know, the first published report on the contents of the trace elements Se, Cr, Rb, Fe, Co, Sb, Ba, Ni, Ag, Hg and Sn in tartary buckwheat grain, flour and bran.

The purpose of this research was to compare the trace element contents of common and tartary buckwheat and to evaluate the possibility of utilizing products of the two species as a source of dietary trace elements.

2. Material and methods

2.1. Buckwheat samples

Common buckwheat cv. Siva, was grown in Dolenjska, Slovenia, and a domestic population of tartary buckwheat in Islek, Luxemburg, both in 1999.

2.2. Milling process

The buckwheat was milled by a flint-stone mill (Bergerac; Dordogne, France), with a capacity of 110 kg/h. Flour, bran and husk milling fractions were collected. Yields were:

- common buckwheat: flour 55.4%, bran 24.2%, husk 17.4%, milling losses 3.0%.
- tartary buckwheat: flour 55.6%, bran 24.4%, husk 15.7%, milling losses 4.3%.

By further sieving to remove coarse particles, flour was refined to a yield of 42.0%, giving a fine tartary buckwheat flour.

Herbs of tartary buckwheat plants were harvested at the beginning of flowering, and dried and milled to give green buckwheat leaf flour.

All procedures were repeated and analysed independently four times.

2.3. Analytical methods

Trace elements were determined by activation analysis, according to Gambelli, Belloni, Ingrao, Pizzoferrato, and Santaroni (1999). Briefly, samples were, without any pretreatment, enclosed in pure quartz vials and irradiated in the 1 MW Triga Reactor for about 14 h in a thermal neutron flux of approximately 2.6×10^{12} n/cm^2/s. Standard reference materials were also irradiated at each run. After an appropriate cooling time, the samples were transferred to polyethylene containers and measured by gamma spectrometry using high purity germanium detectors.

2.4. Statistical analysis

The data were analysed statistically using STATG (Statgraphics 5.0, Statistical Graphics Corporation, USA).

3. Results and discussion

The contents of the elements studied in common and tartary buckwheat are given in Tables 1 and 2. In bran, the contents of selenium, zinc, cobalt, nickel, rubidium, and silver were higher than in flour. Refined tartary buckwheat flour (42% extraction rate) had even lower contents of these elements than normal tartary buckwheat flour (55% extraction rate).

The proteins in buckwheat are relatively poorly digested (Ikeda, Kusano, & Yasumoto, 1986; Skrabanja et al., 2000), and this is connected with its effects on lowering serum estradiol (Kayashita et al., 1999; Liu et al., 2001). The relatively high content of proteins in buckwheat bran milling fractions (Bonafaccia et al., 2003) indicates the potential of this product for dietary use, and as a source of Se, and Zn, which can be bound to proteins in plants (Ikeda et al., 1990; Olson, Novacek, Whitehead, & Palmer, 1970; Sathe, Mason, & Weaver, 1992; Wang, Xie, & Peng, 1996; Yasumoto, Suzuki, & Yoshida, 1988). These expectations are confirmed by the results reported in the present paper. The distributions of rubidium, cobalt, chromium, and iron between the utilisable milling fractions are similar to those of Se and Zn. Steadman et al. (2001) obtained comparable distributions of trace elements in milling

Table 1
Contents of selenium (Se), zinc (Zn), iron (Fe), cobalt (Co), and nickel (Ni) in common and tartary buckwheat and their milling products (mg/kg, dry-weight basis±S.D.[a])

Element	Species	Grain	Bran	Flour	Fine flour	Leaf flour
Se	Common	0.019±0.002	0.046±0.012	0.032±0.006		
	Tartary	0.039±0.020	0.058±0.006	0.018±0.011	<0.010	0.529±0.016
Zn	Common	26.0±0.260	30.2±0.302	20.1±0.201		
	Tartary	35.0±0.350	78.8±0.788	26.3±0.263	14.3±0.143	29.2±0.292
Fe	Common	60.5±0.605	90.6±0.906	82.7±0.827		
	Tartary	462±4.62	147±1.47	149±0.49	37.3±0.373	1607±16.07
Co	Common	0.167±0.002	0.174±0.002	0.167±0.002		
	Tartary	0.528±0.005	0.588±0.006	0.101±0.001	0.022±0.001	4.15±0.042
Ni	Common	1.10±0.110	1.96±0.294	1.00±0.151		
	Tartary	3.11±0.529	3.91±0.117	1.87±0.243	1.14±0.239	3.64±0.546

[a] Standard deviation for four independent determinations.

Table 2
Contents of rubidium (Rb), antimony (Sb), silver (Ag), mercury (Hg), chromium (Cr) and tin (Sn) in common and tartary buckwheat and their milling products (mg/kg, dry-weight basis±S.D.[a])

Element	Species	Grain	Bran	Flour	Fine flour	Leaf flour
Rb	Common	12.8±0.128	14.3±0.142	9.58±0.479		
	Tartary	7.33±0.015	14.8±0.148	5.53±0.055	1.72±0.052	15.8±0.158
Sb	Common	0.006±0.001	0.007±0.001	0.006±0.001		
	Tartary	0.030±0.003	0.014±0.001	0.012±0.001	<0.005	0.158±0.003
Ag	Common	0.027±0.003	0.032±0.005	0.019±0.002		
	Tartary	0.012±0.002	0.017±0.002	0.008±0.003	0.004±0.001	0.040±0.008
Hg	Common	<0.010	0.009±0.004	<0.010		
	Tartary	<0.010	<0.010	<0.010	<0.010	<0.010
Cr	Common	0.138±0.014	0.165±0.002	0.164±0.013		
	Tartary	1.17±0.070	0.249±0.015	0.316±0.009	0.100±0.014	<5.78±0.058
Sn	Common	<0.010	<0.010	<0.010		
	Tartary	2.26±1.13	1.31±0.656	1.07±0.537	<0.010	4.40±0.923

[a] Standard deviation for four independent determinations.

fractions of common buckwheat grown in the USA (tartary buckwheat was not studied). Some of these elements are possibly attached to inositol phosphate (Sandberg, 1999), which is located mainly in the embryo of buckwheat, and thus mostly in the bran fraction (Kreft, Plestenjak, Golob, Skrabanja, Rudolf, & Draslar, 1999). The availability of trace elements in food may depend on their inclusion in the cell structures, on the possible interactions with other constituents, and on the food treatment and processing conditions (Hurrel, 1999; Kreft & Kreft, 1999; Sandberg, 1999; Steadman et al., 2001). Ikeda et al. (1990) found that about 40% of buckwheat flour zinc was in a water-soluble form, and up to 70% was solubilised after peptic and pancreatic enzyme digestion. These solubility data were later confirmed on several different samples of common buckwheat (Ikeda, Tomura, Yamashita, & Kreft, 2001). Approximately 20% of the zinc of raw common buckwheat noodles was found to leak into the water soak during cooking (Ikeda & Shimizu, 1993).

In contrast to the first group of trace elements, there are others, namely iron, rubidium, and chromium, which are equally distributed in flour and bran fractions. Surprisingly, there is even more chromium in flour than in bran of tartary buckwheat (Table 2).

Results (Tables 1 and 2) showed that the distribution of trace elements between flour and bran is not very different in common and tartary buckwheat. The composition is similar in the two species and is characterised by a high content of Zn, amounting to about 78 mg/kg in tartary buckwheat bran. Similar zinc contents were reported earlier for common buckwheat (Ikeda et al., 2000).

Tartary buckwheat bran is a valuable food material, due to its content of protein, dietary fibre, and vitamins B1, B2 and B6 (Bonafaccia et al., 2003). The present results indicate that 50 g of tartary buckwheat bran contains about half the minimal daily recommended intake of zinc and chromium, but only about 5% of the recommended reference daily intake of selenium. The recommended reference daily intake is enough, or more than enough, for about 97% of people in a population, according to Food Standards, (2000).

Fifty grams of the tartary buckwheat bran studied here contains just under the tolerated daily intake of nickel, but would be well under the upper limit of the tolerated daily intake (0.043 mg/day for a 60 kg person) of mercury (Food Standards, 2000).

In contrast to flour and bran, leaf flour, obtained by milling the green parts of tartary buckwheat, has much higher levels of studied trace elements than products obtained from buckwheat grain. This is observed particularly for antimony, selenium, cobalt, chromium, silver and iron, but not for zinc, rubidium or mercury (Tables 1 and 2).

In the samples studied, mercury content was close to or below the detection limit of the present method (Table 2).

The actual availability of these elements in food may depend on their inclusion in the plant structures, on possible interaction with other constituents, on the food treatment and processing conditions, and on the individual genetic and physiological make-up of the consumer. However the content of trace elements in buckwheat materials provides basic information about the potential dietary source of the elements.

4. Conclusion

The comparative study of the elemental composition of the main utilisable grain milling fractions of common and tartary buckwheat has shown that the bran fraction has a higher content of selenium, zinc, cobalt, nickel, rubidium, and antimony, than flour. Refined tartary buckwheat flour (42% extraction rate) had an even lower content of these elements than normal flour (55% extraction rate). Certainly buckwheat is an excellent food material with a potential for use in preventive nutrition.

Tartary and common buckwheats have a potential, not only as functional foods, but also as ‘‘ethnic’’ foods from different parts of Europe. They also offer the possibility for designing novel foods by imitating traditional foods which can, for example, be fortified with common or tartary buckwheat bran, rich in proteins, dietary fibre, vitamins B1, B2, B6, and trace elements.

Acknowledgements

The authors gratefully acknowledge the cooperation of Mr. Christian Zewen, Administration des Service Techniques de l‘Agriculture, Division Agronomique, Service de la mutualité agricole, Luxemburg, for providing the samples of tartary buckwheat and for suggestions, and of Mr. Diego Filippini, Filippini s.p.a., Teglio, Italy in the production of milling products.

This research was supported by the Ministry of Agriculture, Luxemburg, the Ministry of Foreign Affairs of Italy, and the Ministry of Education, Science and Sports of Slovenia.

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