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Composition and technological properties of the flour and bran from common and tartary buckwheat

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Abstract

Common buckwheat and tartary buckwheat were milled in a stone mill. The contents of protein, lipid, starch, dietary fibre and vitamins B1, B2 and B6 were analysed in the flour and bran. There was a prevalence of unsaturated fatty acids—C18:1, C18:2, C18:3 and C20:1. In both species most lipid substances are concentrated in the bran. In common buckwheat bran, protein content was 21.6%, and in tartary buckwheat, 25.3%. There were relatively small differences in the contents of vitamins B1 and B2 between the two main utilisable milling fractions, but more substantial differences in the contents of vitamins B6 (up to 0.61 mg/100 g in the tartary buckwheat bran fraction). Total B vitamin content was higher in tartary buckwheat than in common buckwheat. On the basis of these analyses, it can be concluded that tartary buckwheat bran is an excellent food material with a potential for preventative nutrition.

Keywords: Common buckwheat; Tartary buckwheat; Amino acid; Fatty acid; Fibre; Vitamin B

1. Introduction

Two types of buckwheat are used around the world: common buckwheat (*Fagopyrum esculentum*) and tartary buckwheat (*Fagopyrum tataricum*). Which one is used depends on the production zone. Generally, in Europe, USA, Canada, Brazil, South Africa and Australia, the more common buckwheat is grown. The same is true in most Asian buckwheat growing countries, for example Japan, Korea, and the central and northern parts of China. Tartary buckwheat (Lin, Tao, & Li, 1992) is grown and used in the mountainous regions of southwest China (Sichuan). In northern India, Bhutan, and Nepal both types are known, tartary buckwheat being grown in more harsh climatic conditions.

Many buckwheat flour products are quite similar. Buckwheat pasta is used in Italy (pizzoccheri), in Japan, as soba and in Korea and China as extruded noodles and "cats' ears"; also there are buckwheat pizza and "polenta" type buckwheat porridge (zganci in Slovenia, sterz in Austria, soba-gaki in Japan). The products change their name according to the area in which they are produced.

In Europe, buckwheat has been grown for centuries and is now, alongside spelt wheat (Bonafaccia, Galli, Francisci, Mair, Skrabanja, & Kreft, 2000), one of the most important alternative crops, suitable for ecological growing, without the use of artificial fertilizers or pesticides. It is used for flour and groats products in central and eastern Europe (Kreft, 1994). For many years, cultivation of buckwheat declined, but recent interest in old, traditional foods and a re-evaluation of typical regional products, has led to a resurgence in its cultivation. Buckwheat products are known for their resistant starch (Skrabanja, Laerke, & Kreft, 1998; Skrabanja, Liljeberg, Kreft, & Björck, 2001) and as an important source of antioxidative substances (Kreft, Bonafaccia, & Zigo, 1994; Kreft, Skrabanja, Ikeda, Ikeda, & Bonafaccia, 1996; Kreft, Knapp, & Kreft, 1999; Nagai, Sakai, Inoue, Inoue, & Suzuki, 2001; Park et al., 2000; Watanabe, 1998), trace elements (Ikeda & Yamashita, 1994), and dietary fibre (Steadman, Burgoon, Lewis, Edwardson, & Obendorf 2001). Buckwheat proteins have a high biological value, but relatively low true digestibility (Skrabanja, Nygaard, & Kreft, 2000). Buckwheat protein products have been

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associated with preventative nutrition. In experimental animals they suppress gallstone formation better than soy protein isolate (Tomotake, Shimaoka, Kayashita, Yokoyama, Nakajoh, & Kato, 2000). They are associated 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). There are, however, only a few reports on the technological quality of buckwheat (Bonafaccia & Kreft, 1994; Ikeda, 1997; Ikeda, Kishida, Kreft, & Yasumoto, 1997).

Common buckwheat is grown in all parts of Slovenia. The 'green' social attitude here is widespread (Vadnal, 1993), so it is important to develop and to extend environmentally-conscious technologies and to increase the growing of alternative crops such as buckwheat. In Italy, common buckwheat is grown in the Alpine region (Valtellina and Val Venosta) and is used for preparing typical, regional food products. Tartary buckwheat was grown in both countries in past centuries but, since about 1980, this has ceased. As far as we know, the cross border region Islek—which covers 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 the tartary buckwheat is still grown for human food, on approximately 50 ha. The Luxemburg ministry of agriculture has charged the University of Ljubljana to perform a pluriannual research project in order to develop the cultivation and utilization of tartary buckwheat.

As mentioned above, some studies have been reported on compositional and nutritional characteristics, including contents of rutin, quercetin, polyphenols and minerals, but there is little information about the quality of lipids, the content of B vitamins and about technological parameters, like granulometry and colour, in common and tartary buckwheats.

The aim of this study was to compare the chemical composition of common and tartary buckwheats and to evaluate the main utilisable grain milling fractions of the two species.

2. Material and methods

2.1. Buckwheat samples

Common buckwheat cv. Siva, grown in Dolenjska, Slovenia in 1999, and a domestic population of tartary buckwheat from Islek, grown in 1999 in the northern part of Luxemburg, were used.

2.2. Milling process

The milling process was performed by a flint-stone mill (Bergerac; Dordogne, France), with a capacity of 110 kg/h. The stone mill was used to respect as much as possible traditional buckwheat milling practice. Different milling fractions were obtained: flour, bran and husk fraction.

Milling 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%.

All procedures were repeated and analysed independently three times.

2.3. Chemical analyses

Amino-acid analyses were performed using Beckman System Gold (Moore, Spackman, & Stein, 1958). AACC (1995) methods were used to determine moisture content (44–15A). Protein was determined by the Kjeldahl method (979.09; AOAC, 1990), using a nitrogen to protein conversion factor of 5.75. Ash was determined according to the method of ICC (1990). Starch was determined by the glucose oxidase/peroxidase assay for glucose (Karkalas, 1985), performed on samples after the dual alpha-amylase and amyloglucosidase hydrolysis (Holm, Björck, Drews, & Asp, 1986). Lipids were extracted with chloroform and methanol (2:1 v/v), trans-esterified with BF_3, and analysed by gas chromatography with a capillary column (SP 2330, 30 meter, Supelco, Palo Alto CA, USA) and a flame ionisation detector. Fatty acids were identified by comparison with a chromatographic profile of standards (Finotti, Moretto, Marsella, & Mercantini, 1993). Lipid content was determined by the method 985.29 according to AOAC (1990). Vitamins were analysed by HPLC (WATERS 625 LC System, WATERS 486 tuneable absorbance detector, Milford, MA 01757, USA) according to Hasselmann, Frank, Grimm, Diop, and Soules (1989) and Rees (1989). Dietary fibre was determined according to Prosky, Asp, Schweizer, Devries, and Furda (1988). All analyses were performed in three independent determinations.

2.4. Granulometry analysis

Granulometry analysis was performed by an automatic sieve (Buhler ML1–300) with circular oscillation. Running time was 5 min, oscillation frequency 200 turns/min, with a run of 25 mm.

2.5. Colour

Colour value (L^*, a^* and b^*) analysis was performed using a reflectance colorimeter Minolta, Chroma-Meter Cl-200, according to method CIE (1971).

L^* value is the brightness of the colour in the range of values from 0 (black) to 100 (white); the higher the values, the brighter the colour. The value of a^* indicates the redness of sample namely −(green) to + (red). The b^* value indicates the yellowness of the sample namely −(blue) to + (yellow).

2.6. Statistical analysis

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

3. Results and discussion

3.1. Chemical composition

The chemical composition of common buckwheat is given in Table 1. In the bran, protein content was above 21%, and lipid content around 7%. In the flour, these values were 10% for protein and 2% for lipid content. For tartary buckwheat, the trend was the same (Table 2) and the protein content of the bran was about 25%.

The value of buckwheat proteins in the diet for preventative nutrition was noted in the Introduction. Buckwheat has proteins of relatively low digestibility (Eggum, Javornik, & Kreft, 1980; Ikeda et al., 1986; Skrabanja et al., 2000), and this may explain the effects on lowering serum estradiol. The relatively high content of proteins in buckwheat bran milling fractions indicates their potential for preventative nutrition.

Fibre analysis (Tables 1 and 2) showed that common and tartary buckwheat contain similar amounts. The soluble fraction was found especially in the bran, at levels of around 1%. Our analyses showed a somewhat higher proportion of soluble fibre in tartary buckwheat than in common buckwheat, but this may well depend on the varieties studied. Such results may depend, also. on growing conditions and milling methods. Steadman et al. (2001) obtained comparable results for common buckwheat grown in the USA (tartary buckwheat was not studied), but the proportion of soluble fibre in total fibre was higher in their samples.

3.2. Amino acid composition

The amino acid compositions of the flour and bran products of common and tartary buckwheat are reported in Table 3. The amino acid composition is similar in the two buckwheat species and is characterized by a high lysine content, amounting to about 6 mg/100 g of proteins. Similar amino acid composition results were reported earlier for common buckwheat (Pomeranz & Robins, 1972; Bonafaccia & Kreft, 1994).

3.3. Vitamins

The samples showed a good content of B vitamins, as seen in Table 4. Because vitamin B_1 (thiamine) is involved mainly in energy metabolism, recommended levels of this compound are defined in comparison to energetic uptake, and generally the requirement is 0.4 mg/1000 kcal (Commission, 1993). Tartary buckwheat flour (200 g) satisfy the daily requirement for a diet of 2000 kcal.

There are relatively small differences in the contents of vitamins B1 and B2 between the two main utilisable milling fractions, but more substantial differences in the content of B6 vitamins (up to 0.61 mg/100 g in the tartary buckwheat bran fraction). Tartary buckwheat bran (100 g) contains about 6% of the daily therapeutic doses

Table 1
Chemical composition of common buckwheat and milling products (% dry-weight basis ± S.D.[a])

	Protein	Ash	Fat	Starch	Dietary fibre			
					Total	Soluble	Insoluble	% sol.
Grain	11.7 ± 0.04	2.19 ± 0.01	2.88 ± 0.06	55.8 ± 0.15	27.38 ± 0.19	0.78 ± 0.07	26.60 ± 0.16	2.85
Bran	21.6 ± 0.08	4.08 ± 0.01	7.20 ± 0.04	40.7 ± 0.21	26.37 ± 0.27	0.91 ± 0.10	25.46 ± 0.25	3.45
Flour	10.6 ± 0.04	1.82 ± 0.02	2.34 ± 0.08	78.4 ± 0.27	6.77 ± 0.18	0.88 ± 0.06	5.89 ± 0.12	12.99

[a] Standard deviation for three independent determinations.

Table 2
Chemical composition of tartary buckwheat and milling products (% dry-weight basis ± S.D.[a])

	Protein	Ash	Fat	Starch	Dietary fibre			
					Total	Soluble	Insoluble	% sol.
Grain	11.1 ± 0.01	2.81 ± 0.01	2.81 ± 0.09	57.4 ± 0.12	25.97 ± 0.35	0.54 ± 0.09	25.43 ± 0.24	1.73
Bran	25.3 ± 0.06	4.97 ± 0.01	7.35 ± 0.11	37.6 ± 0.31	24.76 ± 0.26	1.18 ± 0.07	23.58 ± 0.21	4.77
Flour	10.3 ± 0.02	1.80 ± 0.01	2.45 ± 0.08	79.4 ± 0.29	6.29 ± 0.12	0.52 ± 0.09	5.77 ± 0.11	8.27

[a] Standard deviation for three independent determinations.

of pyridoxine, effective (along with folic acid and vitamin B12) in the reduction of blood plasma homocysteine levels and in the decrease of the rate of restenosis after coronary angioplasty (Schnyder et al., 2001).

Table 3
Amino acid composition of common and tartary buckwheat products (g/100 g protein)

	Common buckwheat		Tartary buckwheat	
	Bran	Flour	Bran	Flour
Ala	4.35	4.63	4.31	4.69
Arg	10.5	9.91	11.0	9.63
Asp	10.3	10.2	10.1	10.3
Cys	2.06	2.73	2.61	2.66
Glu	18.8	17.6	18.4	17.1
Gly	6.11	6.09	6.01	5.92
His	2.66	2.47	2.73	2.62
Ile	3.77	3.93	3.96	4.23
Leu	6.51	6.92	6.35	7.11
Lys	5.47	5.84	5.88	6.18
Met	1.09	1.41	1.33	1.42
Phe	4.54	4.62	4.46	4.71
Pro	4.04	4.45	4.08	4.52
Ser	5.17	5.02	5.20	5.19
Thr	3.55	3.71	3.47	3.72
Tyr	2.71	2.70	2.85	2.87
Val	5.13	5.23	5.19	5.19

The B vitamin content is higher in tartary buckwheat than in common buckwheat. Some difference in the content of Vitamin B2 (riboflavin) was found between flour and bran. The highest quantity of this vitamin is concentrated in the bran, with 0.21 and 0.32 mg /100 g for the common and tartary buckwheat, respectively.

Given the superior protein content and the B vitamin profile, tartary buckwheat bran exhibits the properties of an excellent food material.

3.4. Fatty acid composition

The fatty acid composition in common and tartary buckwheat are listed in Table 5. In the common buckwheat, unsaturated fatty acids (C18:1, C18:2, C18:3, C20:1) prevail. In the tartary buckwheat, there is relatively less unsaturated fatty acid and instead more of the principal saturated fatty acids C16:0 and C18:0, as reflected in the unsaturated/saturated fatty acids ratio.

In both species, most lipid substances are concentrated in the bran fraction.

3.5. Granulometry analysis

The granulometry values of milling products, flours and bran, for common and tartary buckwheat, are presented in Fig. 1. In the flours studied, the size of the

Table 4
Contents of vitamins B1, B2 and B6 in common and tartary buckwheat and their milling products (mg/100 g)

	Vitamin B1 (thiamine)	Vitamin B2 (riboflavin)	Vitamin B6 (pyridoxine)
Common buckwheat			
Grain	0.22±0.06	0.10±0.03	0.17±0.04
Bran	0.31±0.08	0.21±0.03	0.58±0.06
Flour	0.28±0.02	0.14±0.05	0.15±0.04
Tartary buckwheat			
Grain	0.41±0.04	0.12±0.02	0.25±0.03
Bran	0.61±0.08	0.32±0.04	0.61±0.06
Flour	0.40±0.07	0.28±0.02	0.18±0.03

Table 5
Fatty acid composition of common and tartary buckwheat (g/100 g total fatty acids)

Fatty acid	Common buckwheat (%)	Tartary buckwheat (%)
Myristic (C14:0)	0.0	0.0
Palmitic (C16:0)	15.6	19.7
Palmitoleic (C16:1)	0.0	0.0
Stearic (C18:0)	2.0	3.0
Oleic (C18:1)	37.0	35.2
Linoleic (C18:2)	39.0	36.6
Linolenic (C18:3)	1.0	0.7
Arachidonic (C20:0)	1.8	1.8
Eicosaenoic (C20:1)	2.3	2.0
Behenic (C22:0)	1.1	0.8
Saturated	20.5	25.3
Unsaturated	79.3	74.5
Unsaturated/saturated	3.87	2.94

particles is very similar, with a prevalence of particles in the range from 130 to 85 μm. In the milling products of tartary buckwheat, there was a higher proportion of bran (particles > 363 μm). Larger particles are mainly parts of the cotyledons, folded through the endosperm. Flour consists mainly of the endosperm particles.

The higher percentage of milling losses in tartary buckwheat is probably due to the small size of some tartary buckwheat grains, which could be lost during the sieving and milling process.

3.6. Colour

Results of the colour analysis are shown in Fig. 2. *L** value is the brightness of the colour in the range of values from 0 to 100; the higher the values the brighter being the colour. In the samples tested in this study, the brightness component of the seed is lighter than that of the milling products. The common buckwheat cultivar studied is the Slovenian cv. Siva, which has an exceptionally light silver grey grain husk, while many other common buckwheat cultivars, especially those originating in Russia, Canada and Asia have dark grains (darker than tartary buckwheat), and some even nearly a black grain husk colour.

No substantial differences between common buckwheat and tartary buckwheat were observed in any of the characteristics studied. Higher *a** and *b** values in tartary buckwheat milling products indicate that they have a slightly stronger yellow-red cast.

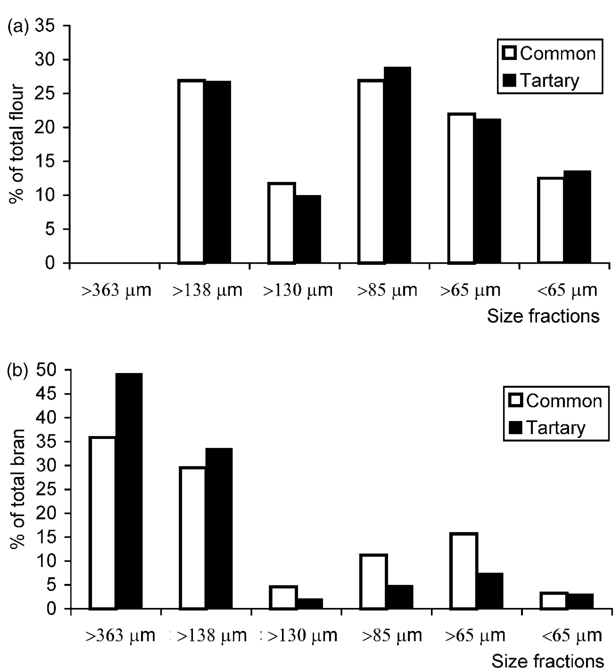

Fig. 1. Percentage distribution of sieving fractions (granulometry analysis) of common and tartary buckwheat flour and bran.

4. Conclusion

The comparative study of the chemical composition of the main utilisable grain milling fractions of common and tartary buckwheat has shown that bran of tartary buckwheat has even higher thiamine, riboflavin and pyridoxine content than common buckwheat products. In addition to the relatively good fatty acid composition, the high dietary fibre and protein content of bran of tartary buckwheat, the vitamin B levels make it an excellent food material with a potential for use in preventative nutrition.

Tartary and common buckwheats have a potential, not only as functional foods, but also as 'ethnic' foods of local traditions in different parts of Europe. It would also be possible to design some novel foods by imitating traditional foods. As bread is readily available, cheap and nutrious and may, in some European countries, constitute the main part of one or more of the daily meals (Tas & El, 2000), it is a challenge to fortify bread with tartary buckwheat bran. There is a rapidly growing

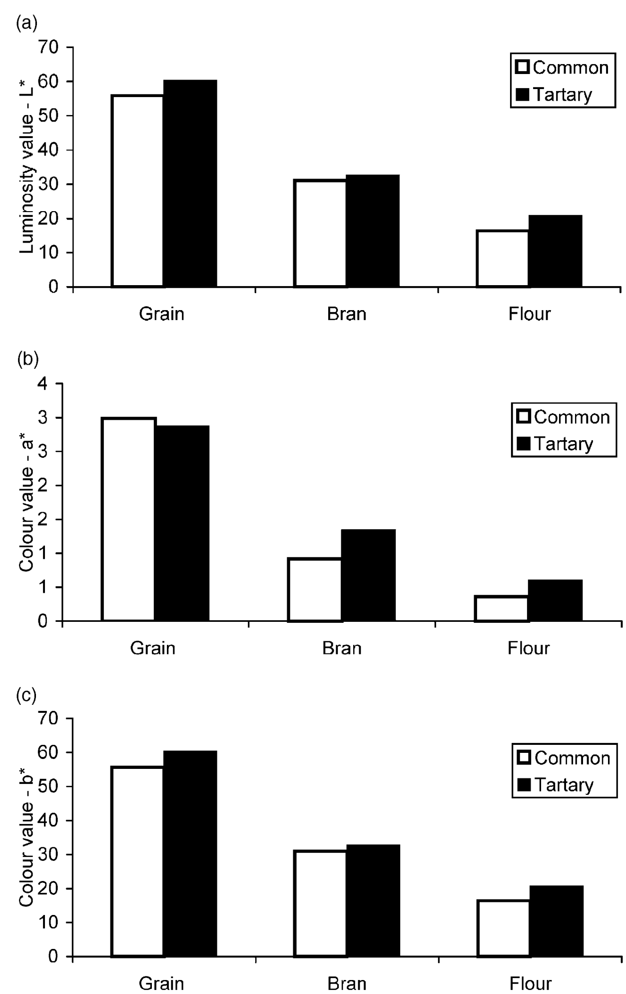

Fig. 2. Colour values (*L**, *a** and *b**) for common and tartary buckwheat grain, bran and flour.

interest in this type of functional food product in Europe.

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