



## CHEMICAL COMPOSITION OF BUCKWHEAT PLANT (*Fagopyrum esculentum*) AND SELECTED BUCKWHEAT PRODUCTS

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### ABSTRACT

The aim of this study was to determine chemical composition of buckwheat plant (*Fagopyrum esculentum*) and products made from its seeds. From the products, peels, groats, flour and wholemeal flour were chosen. Samples were dried and ground to a fine powder. All analyses, except rutin concentration, were determined according to the Commission Regulation no.152/2009. Rutin concentration was performed by the modified method. Almost in all studied samples, the moisture content was about 6 to 8%. The lowest content of moisture was found in roots, 4.3% and the highest was discovered in both flours, about 12%. From buckwheat products, the lowest amount of crude protein was found in peels, 3.5%. On the other hand, the highest crude protein amount of the buckwheat plant was determined in leaves, 22.7%, and in blossoms, 19.1%. The starch content differs from one sample to another. In buckwheat products, its content was about 60 to 70% in dry matter. From all examined samples, the lowest content of fat was found in peels, 0.6%. The greatest concentration of rutin was determined in blossoms and leaves, 83.6 and 69.9 mg per g, respectively. On the other hand, the lowest concentration of rutin was found in buckwheat products, less than 1 mg per g in dry matter. All obtained values, when compared with literature, can differ. Experiments are influenced by the laboratory temperature, method of analysis, reagents and also by the variety of the buckwheat plant.

**Keywords:** chemical composition, *Fagopyrum esculentum*, plant, products, rutin

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## INTRODUCTION

Buckwheat is one of the traditional crops cultivated in Asia, Central and Eastern Europe (Wijngaard and Arendt, 2006). It is categorized as a pseudocereal, so it shows both differences and similarities with cereals. Common buckwheat (*Fagopyrum esculentum* Moench) is the most common grown species. It is an annual, dicotyledonic plant from the family of *Polygonaceae* (Skrabanja et al., 2004). Its seeds are edible and have triangular shape. Buckwheat does not have too massive root system, but its physiological activity is significant. Buckwheat roots excrete formic, acetic, citric and oxalic acids which help the plant to take nutrients, mainly phosphorus, from hard available forms. The stalks are hollow and their colour is green to red. Leaves stand alternately on the stalk. Buckwheat inflorescence is formed by 7 to 9 blossoms. They are tiny of white, pink or red colour (Janovská et al., 2009). The buckwheat fruit contains proteins, saccharides, lipids, fiber, vitamins and minerals as basic components. It is a source of dietary minerals like zinc, copper and manganese (Ikeda and Yamashita, 1994). It is also rich in dietary fiber which has a positive physiological effect in the gastrointestinal tract and also significantly influences the metabolism of other nutrients (Halbrech et al., 2005). Buckwheat seeds contain no gluten so they are safe for people with celiac disease (Skerritt, 1986).

Buckwheat can also act in the prevention and treatment of hypertension and hypercholesterolemia and it could be useful in preventing colon cancer. The preventive effect can be connected with the content of dietary fiber in buckwheat. It has become increasingly apparent that dietary fiber components in food may have a positive physiological effect in the gastrointestinal tract and also significantly influence the metabolism of other nutrients (He et al., 1995). Similar effects are associated with the inclusion of resistant starch in the diet. Buckwheat groats contain an important amount of resistant starch and could be useful in preventing colon cancer (Skrabanja et al., 2001; Kreft and Skarabanja, 2002). In different parts of the buckwheat plant and groats, Watanabe (1998), Kreft et al. (1999) and Park et al. (2000) found appreciable amounts of rutin, a secondary plant metabolite that antagonizes the increase of capillary fragility associated with hemorrhagic disease or hypertension in man. It also decreases the permeability of the blood vessels and has an anti-oedema effect, reduces the risk of arteriosclerosis and has antioxidant activity. Rutin (quercetin-3-rutinosid) is a flavonol glycoside synthesized in higher plants as a protectant

against ultraviolet radiation and diseases (**Rozema et al., 2002**). It was firstly detected in *Ruta graveolens* which gave the common name to this pharmaceutically important substance. Among fruits, vegetables and grain crops, grapes and buckwheat are the most important rutin containing food. No rutin was found in cereals and pseudocereals except buckwheat, which can be used as a good source of dietary rutin (**Hagels, 1999**). Most rutin is accumulated in the inflorescence, stalks and upper leaves (**Kreft et al., 2006**).

The aim of this study was to determine chemical composition of buckwheat plant (*Fagopyrum esculentum*) grown in the Czech Republic and selected buckwheat products, such as peels, groats, flour and wholemeal flour.

## **MATERIAL AND METHODS**

Samples of buckwheat plants and products (peels, groats, flour and wholemeal flour) were obtained directly from the producer in the Czech Republic. They were grown in the region of Slezské Rudoltice. All analyses were realized according to the Official Journal of the European Union (**EC, 2009**) except rutin analysis. It was performed by modified method using information from **Deineka et al. (2004)** and **Gokarn et al. (2010)**.

### **Samples preparation**

Harvested plants were divided into four parts (roots, stalks, leaves and flowers). All samples were dried, ground to a fine powder and sieved through 1 mm mesh. Subsequently, moisture, fat, crude protein, starch and rutin content were determined.

### **Determination of moisture**

First of all, the moisture content was determined using drying to the constant loss of the weight.

### **Crude protein determination**

Crude protein content was determined according to the Kjeldahl method using the Pro-Nitro 1430 apparatus (BIO PRO, Praha). From mineralised samples, prepared according to Kjeldahl, the ammonia released from the reaction of ammonium sulphate with heavy

solution of sodium hydroxide (PENTA, Chrudim) was distilled with water vapour into boric acid solution (PENTA, Chrudim). Incurred ammonium borate was determined by the titration with hydrochloric acid solution (PENTA, Chrudim), using the Tashiro indicator (Fluka, Germany). From the acid consumption, the amount of nitrogen was calculated. The result was recalculated to the sample weight and by multiplying it with the factor 5.7, the percentage of crude protein was obtained.

### **Establishing of starch content**

Samples for starch determination were treated with dilute hydrochloric acid (PENTA, Chrudim). After clarification and filtration the optical rotation of the solution was measured by polarimetry.

### **Fat content determination**

The fat content was determined according to the Soxhlet method. In this method, the fat was hot-extracted using the non-polar solvent, n-hexane (Lach-Ner, Neratovice). In the end of the distillation, the solvent was distilled off and the residue was dried and weighed.

### **Establishing of rutin concentration**

Rutin concentration in all samples was determined using a modified method according to **Deineka et al. (2004)** and **Gokarn et al. (2010)**. Two grams of the sample were extracted with methanol: acetic acid: water (100:2:100). After sonification and shaking, test-tubes were centrifuged at 4000 rpm for 5 minutes and filtrated through 0.45 µm filter. The subsequent HPLC analysis was provided with the Waters symmetry C18 column. Used mobile phase consisted of acetic acid: acetonitrile: methanol (75:15:10), the flow rate was 1 ml per minute, and the detection was performed at 355 nm.

### **Statistical evaluation**

All results were statistically evaluated using the variation statistics (ANOVA). Correlation matrices and regression functions were calculated according to **Snedecor and Cochran (1967)** using the statistical package Unistat, v. 5.5.

## RESULTS AND DISCUSSION

Chemical composition of buckwheat plant and selected buckwheat products, peels, groats, flour and wholemeal flour, was studied. Firstly, moisture content of all samples was determined. It was subsequently recalculated to the dry matter content. Obtained results are presented in Table 1. Almost in all samples, except buckwheat flours, the moisture content was about 6 to 8%. The lowest content of moisture was in roots, 4.3%. On the other hand, the highest moisture was discovered in both flours, about 12%.

**Table 1** Average moisture and crude protein content in studied samples (mean  $\pm$  S.E.) [%]

Sample	Moisture content	Crude protein amount
Roots	4.3 $\pm$ 0.02	5.6 $\pm$ 0.16
Stalks	7.7 $\pm$ 0.01	6.5 $\pm$ 0.03
Leaves	7.5 $\pm$ 0.02	22.7 $\pm$ 0.26
Blossoms	6.5 $\pm$ 0.02	19.1 $\pm$ 0.10
Peels	6.1 $\pm$ 0.08	3.5 $\pm$ 0.05
Groats	8.3 $\pm$ 0.06	13.1 $\pm$ 0.04
Flour	11.5 $\pm$ 0.08	12.9 $\pm$ 0.03
Wholemeal flour	11.9 $\pm$ 0.03	14.4 $\pm$ 0.03

S.E. – standard error

As can be seen from Table 1, the highest crude protein amount of the buckwheat plant was determined in leaves, 22.7%, and in blossoms, 19.1%. From buckwheat products, the lowest amount of crude protein was found in peels, 3.5%. **Edwardson (1996)** presents the protein content in groats as 16.8% and in light flour 11.7%. His value for groats is higher than the one determined in our laboratory experiment, the second one, for the light flour, is lower than the value presented in Table 1.

**Table 2** Average content of starch and fat in examined samples (mean  $\pm$  S.E.) [%]

Sample	Starch content	Fat content
Roots	0	4.3 $\pm$ 0.01
Stalks	1.1 $\pm$ 0.00	2.6 $\pm$ 0.01
Leaves	6.0 $\pm$ 0.00	3.1 $\pm$ 0.01
Blossoms	-	5.7 $\pm$ 0.01
Peels	57.2 $\pm$ 0.18	0.6 $\pm$ 0.01
Groats	69.5 $\pm$ 0.00	3.4 $\pm$ 0.03
Flour	67.9 $\pm$ 0.18	4.1 $\pm$ 0.01
Wholemeal flour	61.6 $\pm$ 0.00	4.1 $\pm$ 0.01

The starch content (Table 2) differs from one sample to another. In buckwheat products, its content ranged from 60 to 70% in dry matter. Very low amounts were found in the plant. The amount of starch was not determined in blossoms because of small amount of the sample. Buckwheat blossoms are very lightweight.

Table 2 also shows the content of fat in all examined samples. The lowest content of fat was found in peels, 0.6%. The highest content of fat was determined in roots and both flours, about 4% in average. **Edwardson (1996)** reports the amount of fat in buckwheat groats, dark and light flour as 3.2, 3.5 and 2.5%, respectively. These values are lower than those obtained in our experiment.

**Table 3** Average concentration of rutin in studied samples [mg per g]

Sample	Rutin concentration
Roots	3.6
Stalks	0.5
Leaves	69.9
Blossoms	83.6
Peels	0.1
Groats	0.1
Flour	0.1
Wholemeal flour	0.6

From Table 3, it can be concluded, that the greatest concentration of rutin was determined in blossoms and leaves, 83.6 and 69.9 mg per g, respectively. On the other hand, the lowest concentration of rutin was found in buckwheat products. **Kreft et al. (2006)** in their study presents the value of rutin concentration in buckwheat groats as 0.2, in dark flour 0.2 and in light flour 0.1 mg per g. The value of rutin concentration in light flour is close to the value obtained in our experiment. Other values are a little bit different.

## CONCLUSION

Buckwheat is a plant from the family of *Polygonaceae*. It contains potassium, phosphorous, calcium, iron, zinc, vitamins B, E and rutin. Rutin is a bioflavonoid which is used for blood vessels treatment. Obtained results confirm that the highest concentration of rutin is accumulated in leaves and blossoms of the buckwheat plant. Usually, they are the main part of tea mixtures used for vessel diseases treatment. On the other hand, the lowest concentration is in buckwheat products. Used buckwheat seeds (groats) were mechanically

peeled. These seeds then have light colour and the preparation does not require any long-time cooking. Technologically, buckwheat flour is processed by milling of groats or by broken groats and the value of dry matter/moisture is depending on the quality of storage. Total crude protein content is influenced genetically, by the area of growing, by weather and soil. Dry weather during buckwheat seeds' creating causes premature ripening; a part of sugars stays in stalks and the amount of crude protein in seeds is increasing.

All experiments could be influenced by many factors, e.g. the variety of the plant, different climatic conditions, processing of the seed, laboratory conditions, reagents, modification of the method, etc.

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## REFERENCES

COMMISSION REGULATION (EC) No 152/2009 of January 17, 2009 laying down the methods of sampling and analysis for the official control of feed. *Official Journal of the European Union*. February 26, 2009, L 54, p. L 54/12-L 54/19. ISSN 1725-2555.

DEINEKA, V.I. – GRIGOREV, A.M. – STAROVEROV, V.M. 2004. HPLC analysis of flavonoids: determining rutin in plant extracts. In *Pharmaceutical Chemistry Journal*, vol. 38, 2004, no. 9, p. 23-25.

EDWARDSON, S. 1996. Buckwheat: Pseudocereal and nutraceutical. In J. JANICK (ed.): *Progress in new crops*. Alexandria: ASHS Press, 1996, p. 195-207.

GOKARN, V. – DIGHE, V. – MENON, S. – KHAIRNAR, B. 2010. Online HPLC-DAD/UV-MS determination of major flavonoids rutin and isoquercitrin in two *Morus* species. In *International Journal of Pharmaceutical Research&Development*, vol. 2, 2010, no. 6, p. 1-15.

HAGELS, H. 1999. *Fagopyrum esculentum* Moench. Chemical review. In *Zbornik BFUL*, vol. 73, 1999, p. 29-38.

HALBRECQ, B. – ROMEDENNE, P. – LEDENT, J.F. 2005. Evolution of flowering ripening and seed set in buckwheat (*Fagopyrum esculentum* Moench): quantitative analysis. In *European Journal of Agronomy*, vol. 23, 2005, p. 209-224.

HE, J. – KLAG, M.J. – WHELTON, M.J. – MO, J.P. – CHEN, J.Y. – QIAN, M.C. – MO, P.S. – HE, G.S. 1995. Oats and buckwheat intakes and cardiovascular disease risk factors in an ethnic minority in China. In *American Journal of Clinical Nutrition*, vol. 61, 1995, p. 366-372.

IKEDA, S. – YAMASHITA, Y. 1994. Buckwheat as a dietary source of zinc, copper and manganese. In *Fagopyrum*, vol. 14, 2004, p. 29-34.

JANOVSKÁ, D. – KALINOVÁ, J. – MICHALOVÁ, A. 2009. *Metodika pěstování pohanky v ekologickém a konvenčním zemědělství. Metodika pro praxi*. Praha 6 - Ruzyně: Výzkumný ústav rostlinné výroby, v.v.i., 2009. ISBN 978-80-7427-000-0.

KREFT, I. – FABJAN, N. – YASUMOTO, K. 2006. Rutin content in buckwheat (*Fagopyrum esculentum* Moench) food materials and products. In *Food Chemistry*, vol. 98, 2006, p. 508-512.

KREFT, S. – KNAPP, M. – KREFT, I. 1999. Extraction of rutin from buckwheat (*Fagopyrum esculentum* Moench) seeds and determination by capillary electrophoresis. In *Journal of Agricultural and Food Chemistry*, vol. 46, 1999, p. 2020–2023.

KREFT, I. – SKRABANJA, V. 2002. Nutritional properties of starch in buckwheat noodles. In *Journal of Nutritional Science and Vitaminology*, vol. 48, 2002, p. 47-50.

PARK, C.H. – KIM, Y.B. – CHOI, Y.S. – HEO, K. – KIM, S.L. – LEE, K.C. *et al.* 2000. Rutin content in food products processed from groats, leaves and flowers of buckwheat. In *Fagopyrum*, vol. 17, 2000, p. 63-66.

ROZEMA, J. – BJÖRN, L.O. – BORNMANN, J.F. – GABERŠČIK, A. – HÄDER, D.P. – TROŠT, T. *et al.* 2002. The role of UV-B radiation in aquatic and terrestrial ecosystems – an



experimental and functional analysis of the evolution of UV-B absorbing compounds. In *Journal of Photochemistry and Photobiology B*, vol. 66, 2002, p. 2–12.

SKERRITT, J.H. 1986. Molecular comparison of alcohol-soluble wheat and buckwheat proteins. In *Cereal Chemistry*, vol. 63, 1986, p. 365-369.

SKRABANJA, V. – KREFT, I. – GOLOB, T. – MODIC, M. – IKEDA, S. – IKEDA, K. – KREFT, S. – BONAFACCIA, G. – KNAPP, M. – KOSMELJ, K. 2004. Nutrient Content in Buckwheat Milling Fractions. In *Cereal Chemistry*, vol. 81, 2004, no. 2, p. 172-176.

SKRABANJA, V. – LILJEBERG, E.H.G.M. –KREFT, I., – BJÖRCK, I.M.E. 2001. Nutritional properties of starch in buckwheat products: studies in vitro and in vivo. In *Journal of Agricultural and Food Chemistry*, vol. 49, 2001, p. 490–496.

SNEDECOR, G.W. – COCHRAN, W.G. 1967. *Statistical Methods*, 6<sup>th</sup> edit., Iowa: Iowa State University Press, 1967, p. 579.

WATANABE, M. 1998. Catechins as antioxidants from buckwheat (*Fagopyrum esculentum* Moench) groats. In *Journal of Agricultural and Food Chemistry*, vol. 46, 1998, p. 839–845.

WIJNGAARD, H.H. – ARENDT, E.K. 2006. Buckwheat. In *Cereal Chemistry*, vol. 83, 2006, no. 4, p. 391-401.