

NUTRITIONAL AND HEALTH ASPECTS OF BUCKWHEAT- A CONCISE REVIEW

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Article Received on
04 June 2016,

Revised on 25 July 2016,
Accepted on 15 August 2016

DOI: 10.20959/wjpr20169-6943

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ABSTRACT

Buckwheat is a pseudo cereal grown on degraded lands which are declared as unproductive for other crops. Thus different varieties of buckwheat are used in different countries including many Asian and European countries. Buckwheat is a good source of complex carbohydrate, fiber, protein and also contains a variety of minerals and vitamins. It exhibit very high antioxidant activity and flavanoids such as rutin which can affect the activity of enzyme angiotensin I, involved in controlling blood pressure. Buckwheat products have been shown to improve glucose and insulin responses in diabetic subjects because of the presence of rutin, dietary fibre, fagopyritols, chromium and alum. Buckwheat protein helps in preventing cancer, and possesses antifungal activity. Throughout the world a large range of foods are made from buckwheat such as noodles, pasta, polenta, bread, cakes,

pancakes, dumplings, groats dishes, beer, honey etc. So the present paper focuses on the nutritional importance of buck-wheat, its uses, and health benefits.

KEYWORDS: Buckwheat groats, flavanoids, fagopyritol, rutin, phytochemicals, diabetes.

1. INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench), family *Polygonaceae*, classified as a pseudo-cereal, is one of the traditional crops cultivated in central and eastern Europe and in Asia and now it is one of the crop used as alternative crops for organic cultivation and for healthy foods^[1]. Originating from Asia and introduced into Europe around the 15th century, the cul-

tivation of buckwheat has spread to Canada, the United States of America and to certain areas of Africa and Latin America, with an annual yield, worldwide, approximately one million tons. The agricultural features which have encouraged its cultivation in such varied regions are primarily that buckwheat is semi-wild, does not require any particular soil for cultivation nor have any particular fertilization requirements and can, furthermore, grow above 3,000 meters in Nepal and Bhutan^[2]. Common buckwheat (*Fagopyrum esculentum* Moench) is herbaceous erect annual plant with diploid chromosome number $2n=16$. It has been the crop of secondary importance in many countries, grown on the marginal unproductive land, being used as sub-sistence crop in many of the mountainous area where it is grown with barley and other cereals at higher altitudes^[3]. In comparison with traditional cereals, buckwheat proteins are high in lysine, which makes it interesting from a nutritional point of view and also gluten free. It could therefore be used as a substitute for wheat in gluten-free diets for celiac patients. Buckwheat flour contains some essential nutrients at a high level. Therefore, buckwheat is a good and promising source of such essential nutrients. In view of its beneficial effects on human health, increasing attention to buckwheat as a functional food has been currently paid. It is considered that buckwheat and its products are food with high nutritional and therapeutic value.

2. Nutrient and antinutrient composition of buckwheat

Buckwheat is a good source of complex carbohydrate, fiber, protein and also contains a variety of minerals and vitamins. Buckwheat seeds have also been shown to exhibit very high anti-oxidant activity, even higher than that of other grain like oats, barley, wheat, rye and most fruits and vegetables^[4].

2.1. Nutritional Composition

2.1.1 Proximate composition of buckwheat

Protein content of whole buckwheat grain ranges from 8.51 to 12.28 percent^[5] while its amount varies from 14.6 to 15.8 percent in gluten free flours^[6, 7]. Buckwheat protein consists of well balanced amino acids. It is particularly rich in lysine (5.68%). It contains less glutamic acid (19.38%) and proline (7.93%), arginine (11.16%), aspartic acid (9.54%), tryptophan (2%), threonine (3.5%) and valine (4.26%) as compared to other cereal proteins. Glycine level (5.66%) is much higher than barley, rye, corn, rice and whole wheat^[8]. It is also shown that the ratio of Met/Gly in buckwheat (0.16) is lower than that of other cereal protein sources^[9, 10]. Lysine content of buckwheat is approximately two times higher than found in

wheat flour, similar to value reported for egg white and contents of other amino acids are generally close to that of wheat protein or somewhat higher than wheat protein. The high-quality buckwheat proteins can complement cereal and legume proteins because of the high levels of lysine as well as arginine^[6, 11, 12]. Apparent digestibility of buckwheat protein ranges from 46.7 to 67.1^[6,13]; true digestibility varies from 78.8 to 80.8^[14,15]; net protein utilization is 67 to 74.4 and biological value is 90.5 to 93.1 as compared to 53.0 and 55 of wheat flour and rice, re-spectively^[14]. Buckwheat has been recommended as a good source of plant protein which has similar biological value compared to animal protein^[6].

Buckwheat grains are excellent source of fibre. Crude fibre content in whole grains varies from 11.9 to 17.8 percent ^[6,13,14]; neutral detergent fiber varies from 17.5 percent in common whole buckwheat flour^[16] to 32.3 percent in tartary buckwheat and acid detergent fiber is 22.4 percent^[13]. Total lipid in buckwheat ranges from 2.6 to 3.2 percent of which 81 to 85 percent are neutral lipids, 8 to 11 percent is phospholipid and 3 to 5 percent is glycolipid. Free lipid ranges from 2.11 to 2.3 percent. The major fatty acids of all classes of lipids are palmetic (16:0), oleic (18:1) and linoleic acid (18:2)^[17,18].

The range of starch content of buckwheat grains (dehulled buckwheat grains) is 37 to 70 percent (dry weight basis) depending upon the species^[19]. Soluble carbohydrate in buckwheat ranges from 48.7 to 55.2 percent as compared to 81.2 percent of wheat^[14]. Buckwheat starch granule is 1.0 to 11.4 μm in size^[20,21]. Slightly longer than rice, it has amylase content of 25 percent, gelatinization temperature of 66.3 to 70.8°C and starch swelling volume of 27.4 to 30.8 ml in comparison to 63.8°C and 20.1 ml for wheat starch^[22]. Physiological properties of buckwheat starch affect functional properties of food especially composite flour products containing buckwheat. Kumari and Raghuvanshi^[23] studied the physiochemical and functional properties of buckwheat grains and found out that buckwheat grain has good physical, physiochemical and functional properties so it can be used in different types of food products. Total starch, rapidly digestible starch, slowly digestible starch and resistant starch is 76.0, 9.50, 28.7 and 37.8 percent in untreated buckwheat groats. Groats prepared by using traditional procedur method of cooking before dehussing followed by warm air drying, have less than 48 percent (dry matter basic) of rapidly available starch in comparison to white wheat bread, where the corresponding value is almost 59 percent^[24]. Thus buckwheat groat starch with reduced rate of digestion can be possible complement to or a substitute for common carbohydrate source and has several nutritional and clinical implications.

2.1.2 Minerals in buckwheat

Cereals, including buckwheat, can serve as an important source for supplying some essential nutrients due to their large daily consumption. Besides providing protein and energy, buckwheat may be a valuable source of minerals for those who consume it. Ash content in buckwheat varies from 2.3 to 2.6 percent compared to 1.6 percent in wheat indicating that buckwheat is a good source of minerals^[14]. Buckwheat flour contain high level of zinc, copper, manganese, magnesium, potassium and phosphorus in comparison to other cereals as a polished rice and wheat flour providing about 20 to 100 percent of the RDA of these minerals per 100 gm^[25]. Range of zinc content in flour of various buckwheat varieties ranges from 0.63 to 3.38 mg/100gm dry matter, of dietary copper is 0.41 to 0.91mg/100 gm: manganese 0.73 to 2.48mg/100 gm^[25-27] magnesium (254-302 mg/100gm): potassium (471 to 530mg/100gm), phosphorus (381 to 500mg/100 gm) and calcium (15.1 to 72.7mg/100gm). It has been reported that large proportion of zinc, copper and potassium is released in a soluble form from buck-wheat flour by enzymatic digestion and is thus available for gastrointestinal absorption^[25,28]. However, bioavailability of calcium and manganese from buckwheat flour is limited^[25]. Besides the above mentioned six minerals, buckwheat has high amount of selenium and sodium, strontium and lithium than wheat flour^[11,29,30].

2.1.3 Vitamins in buckwheat

Buckwheat groats are better source of riboflavin and niacin with values ranging from 0.11 to 0.28 and from 4.72 to 9.24 mg/100gm, respectively^[7,31,32]. Content of vitamin B6 is also higher in buckwheat flour (5.78 µg/gm) than in other cereal flour like barley, maize, rice rye and wheat, in which it ranges from 0.58 to 3.17 µm/gm^[33]. Total and free vitamin B6 in buckwheat ranges from 6.02 to 7.07 µg/gm and from 1.54 to 2.77 µg/gm, respectively^[34]. Thiamin ranges from 544.2 to 671.3µg/gm in buckwheat^[7,34]. Buckwheat leaves are very good source of beta carotene and ascorbic acid^[30].

2.1.3 Flavonoids in buckwheat

Buckwheat contains many flavonoid compounds, known for their effectiveness in reducing the blood cholesterol, keeping capillaries and arteries strong and flexible, and assisting in prevention of high blood pressure^[35]. Buckwheat has unique amino acid composition with special biological activities. It also contains several components with healing benefits namely flavonoids and flavones, phytosterols, fagopyrins and thiamin binding proteins^[36]. Rutin, the main buckwheat flavonoid, is a flavonol glucoside. The flavonoids content and composition

in buckwheat seeds is affected by species, growing phase and growing conditions. Flavonoids content in seeds of the wild buckwheat (*Fagopyrum tataricum*) is about 40 mg/100g, while in the common buckwheat (*Fagopyrum esculentum*) around 10 mg/100g. Many different flavonoids have been isolated and identified in buckwheat grain. Rutin, orientin, vitexin, quercetin, isovitexin, quercetrin and isoorientin are all present in the hull, while groats contain only rutin and small amounts of isovitexin. It has been established that rutin can affect the activity of enzyme, angiotensin I, involved in controlling blood pressure^[37]. Flavonoids can, therefore, be used as effective drugs to treat some cardiovascular diseases such as arteriosclerosis. These compounds also act as strong antioxidants and can prevent oxidation of DNA and lipoproteins such as LDL, VLDL. Flavonoids are transferred from mother to baby across placenta, and further into fetus brain. These facts suggest that flavonoids are important and essential components for brain development and for maintenance of the nervous system.

2.1. Antinutrients in buckwheat

It has been reported that buckwheat flour has no hemagglutinin activity and tannin content is negligible^[38] and ranging from 0.5 to 4.5 percent according to Franchischi and others^[39]. Verma^[40] has shown that whole buckwheat flour contains negligible amount of tannin (1.46-3.76µg/100g) which was even reduced by an average of 21.66 percent on sieving in different cultivars. Verma^[40] also studied 7 different cultivars of buckwheat and showed that phytate content in whole flours ranged from 623.9 to 995.9 mg/100g while in sieve flour it was reduced by 68.45 percent with values ranging from 184 to 339.4 mg/100g in different cultivars.

3. Uses of buckwheat

Buckwheat seeds are desirable and functional food resource in human living because of many health benefits^[41]. In recent years medicinal effects in clinical applications of buckwheat has been widely investigated and importance of buckwheat as food has been increasingly recognized in the prevention and maintenance diet of several degenerative diseases like cancer, diabetes, heart diseases, hypertension and gall stones^[40].

3.1. Antioxidant Properties

The content of total antioxidant compounds in buckwheat cultivars of Poland, Russia and France ranges from 11.4 to 21.4 mg/ 100gm^[42]. Total antioxidant potential of buckwheat is higher than wheat and barley^[43,44] and is 3.3 times stronger than ascorbic acid^[41]. Buckwheat

hull extract efficiently inhibits the activity of α -amylase and lens aldose reductase^[41]; increases the activity of antioxidant enzymes like super oxide dismutase, catalase and glutathione peroxidase *in vivo*^[45-47]. Thus consumption of buckwheat prevents oxygen free radicals from attacking the cell membranes, thus possessing auto senescence function and reduces lipid peroxidation in blood of rats^[48].

3.2. Role in Heart Disease

Researchers have suggested a role of buckwheat consumption in prevention and treatment of hypercholesterolemia. Buckwheat intake 100gm/ day is associated with lower total serum cholesterol, low lipoprotein cholesterol levels, a higher ratio of HDL to total cholesterol^[16,49]. It has also been reported that extract of *Fagopyrum esculentum* reduces atherosclerotic plaque formation^[50]. Buckwheat with high arginine to lysine ratio (1:90)^[51] has been postulated to be responsible for hyperlipidemic effect (Nagata *et al.*, 1980). Buckwheat also contains soluble dietary fiber and to a lesser extent insoluble dietary fiber. These are fermented by microflora in the digestive system to produce short fatty acids, implicated in serum cholesterol reduction^[1].

3.3. Role in Cancer Prevention

Buckwheat has been used in Chinese traditional medicine or dietary treatment against various kinds of cancer for several decades. Buckwheat flavonoids extracted from malted tartary buckwheat seed possess antitumor activity against mammary cancer^[52] on the other hand (Kayashita *et al.*^[53] as well as Guo *et al.*^[54] had studied that buckwheat ingredient could inhibit mammary cancer by *in vivo* and *in vitro* test but the functional component was proved to be buckwheat protein.

Besides of anti-tumor activity, some multifunctional buckwheat protein still had other biological activities, such as antifungal activity^[55] and protease inhibitory activity^[56].

3.4. Roles in Diabetes

Buckwheat products have been shown to improve glucose and insulin responses in clinical study and many therefore can be of benefit in the treatment and prevention of diabetes. In study done on 1000 resident in Inner Mongolia, the average blood sugar level of people who eat buckwheat as staple food is 3.9 milli mole per liter, compared with 4.56 milli mole per liter among people who don't eat buckwheat. Detectable rates of high blood pressure and diabetes are respectively 1.6 and 1.88 per cent in buckwheat eating areas compared with 7.33

percent and 3.84 percent in regions without the buckwheat eating habit. The research done at Harbin Medical University also found that the blood sugar level of rats dropped from 9.41 milli mole per liter to 7.57 milli mole per liter as a result of 15 day buckwheat diet^[57]. Buckwheat based radicals from attacking the cell membranes, thus possessing auto senescence function and reduces lipid peroxidation in blood of rats^[48].

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3.5. Phytochemicals

Rutin present in buckwheat seeds and sprouts is a flavonol plant metabolite and is able to antagonize the increase of capillary fragility in hemorrhagic disease or hypertension in man^[59,60]. Daily intake of 100 g buckwheat flour in food would therefore approximately meet 10 percent therapeutic dose. It has been speculated that buckwheat bran which contains fagopyritols, may have an important role in the treatment of NIDDM^[61].

3.6. Fiber

Buckwheat is rich source of dietary fibre. The content of TDF in groats may range from 5 to 11%^[62-65]. Bran fractions obtained by milling of buckwheat are especially enriched in dietary fibre (13-16%), but buckwheat flours contain considerably lower amounts of fibre (1.7-8.5%)^[64]. The effect of dietary fiber on glucose metabolism is twofold; acute and long term. The acute effect is the reduction in post prandial glycemia as the result of supplementation of a test meal with dietary fiber. The effect is attributed to the slower gastric emptying and low carbohydrate digestion and absorption. In addition, alteration in the quality of enteroinsular axis may also contribute to the reduction in post prandial glycemia. The long term effect of the dietary fibre on glucose metabolism refers to the improvement in glucose tolerance following a few weeks to a few months of being on high fibre diet. This effect may be due to sustained changes in gastric motility, pancreatic enzyme secretion, intestinal structure hepatic glycolytic enzymes and improvement in peripheral insulin sensitivity^[66].

3.7. Fagopyritols

Fagopyritols are specific carbohydrate compounds first identified in buckwheat and named after the Latin name of this crop. Fagopyritols are mono-, di-, and trigalactosyl derivatives of *D-chiro*-inositol that accumulate especially in the embryo and the aleurone tissues of buckwheat. Among the plant sources, buckwheat is the richest in these carbohydrates. Studies

Have shown that the bran milling fractions may contain 2.6g of fagopyritols per 100g of dry weight, whereas dark and light buckwheat flours contain 0.7g and 0.3g/100g, respectively. It has been reported that D-*chiro*-inositol could positively affect the blood glucose level and insulin activity^[67,68]. Study conducted at the University of Manitoba (Kawa and others 2003) had shown that buckwheat extract could be equally efficient in lowering blood glucose level and activating insulin as synthetic D-*chiro*-inositol. There is also evidence that D-*chiro*-inositol can help to control development of polycystic ovary^[69]. However, the fate of fagopyritols in the human digestive system as well as the amount necessary to be consumed to achieve beneficial effects remain unknown and require further investigation^[65].

3.8. Chromium and Alum Content

It has been found that buckwheat contains more chromium and alum than that found in other foods, thus being beneficial in control of diabetes^[57].

3.9. Glycemic index of buckwheat and buckwheat incorporated products

The glycemic index value of buckwheat ranges from 51 to 78^[70,71]. Starch hydrolysis index of boiled buckwheat groat (BWG) is 50, of boiled buckwheat noodles is 61^[72]. All buckwheat incorporated breads have significantly lower rate of in vitro amylosis ($P \leq 0.05$) in reference to whole bread. Hydrolysis index, calculated glycemic index and insulinemic indices for boiled BWG and 70% BWG incorporated bread was 50, 61, 66 and 54, 66, 74 respectively^[73]. Thus buckwheat has potential use in diet designed in accordance with the dietary recommendations for diabetic patients. Further, buckwheat grains and leaves have been found useful in decreasing fasting blood sugar and cholesterol levels and in diabetic retinopathy. Verma^[40] has formulated products like biscuits, *chapaties* and *namakpar* using buckwheat flour which have low glycemic index as compared to their respective controls. These products also bring about a significant reduction in total cholesterol levels and hold the potential in modulating HDL, LDL and triglyceride components of the blood if consumed regularly on daily basis for a longer time. Verma^[40] also formulated dal, pakora and namakpara by incorporating buckwheat leaf. These products had more amounts of calcium and β -carotene than their respective controls. Shakib and others^[10] conducted the study to investigate the effect of buckwheat yoghurt mixture on serum total cholesterol, LDL-cholesterol, HDL-cholesterol in 20 hypercholester-olemic subjects. Results of this study indicate that incorporation of buckwheat into daily diet markedly improves the serum lipid profile of hypercholesterolemic subjects. Total and LDL-cholesterol concentrations showed a significant decrease. Study

showed significant reductions in triglycerides concentrations with buckwheat consumption. High-density lipoprotein cholesterol increased in study subjects as a result of the buckwheat intervention. HDL cholesterol level is inversely correlated to CVD risk. Moreover, both LDL/HDL and Total cholesterol–HDL ratios decreased significantly in these subjects. Thus, the overall effect of the buckwheat intervention on lipid measures of CVD risk appears to be positive. The present study had also demonstrated that inclusion of BWYM in breakfast of NIDDM subjects led to significant reduction in their fasting and postprandial blood glucose levels from the very start of the intervention of BWYM (day 14) till the end of test period (day 35). So study lead to conclusion that incorporation of 30 g buckwheat in daily diet markedly improved serum lipid profile of hypercholesterolemic subjects and led to a significant reduction in fasting and post prandial blood glucose levels of NIDDM subjects.

4. CONCLUSION

Buckwheat flour can be successfully used to ensure nutrition security. Its grains are good source of dietary fibre. Buckwheat protein consists of well-balanced amino acids with high biological value compared with other cereal proteins. Buckwheat is also known as an abundant source of dietary minerals like calcium, zinc, copper, and manganese. Leaves are a rich source of β -carotene and calcium and can be successfully used to take care of micronutrient deficiencies of the population. Further, buckwheat flour incorporated products can be successfully used in designing foods with low glycemic index for diabetic patients. Regular buckwheat consumption can thus be recommended as a life style intervention to alleviate hypercholesterolemia and diabetes mellitus. Further researches should be undertaken to design functional foods using buckwheat and community trials should be undertaken to see the effects of these functional foods on the health. Efforts should be made to educate people about nutritive value and health benefits of buckwheat and its food products.

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