Buckwheat: A Useful Food and its Effects on Human Health

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Abstract: Buckwheat is a plant used for many purposes, such as consumed as a food and used in the treatment of diseases. It is a good source of many vitamins and minerals and has balanced nutritional value. Because of its nutrient content and many positive effects on human health, buckwheat has become a functional food, recently. Main effects of buckwheat on human health are its hypotensive, hypoglycemic, hypocholesterolemic, neuroprotective and antioxidant effects. Thus, it is considered an alternative food component in dietary treatment for chronic and metabolic diseases, such as diabetes, hypertension and celiac disease. Also, its rich nutrient content supports daily diet and provides a better eating profile. As a result, buckwheat is accepted as a functional food, suggested to improve human health and is used in the treatment of diseases. The aim of this review is to explain some positive effects of buckwheat on human health.

Keywords: Buckwheat, functional food, health effect, nutrition, rutin, tartary buckwheat.

1. INTRODUCTION

1.1. General Properties of Buckwheat

Buckwheat is an annual plant of Polygonaceae family with no relation between grains. It belongs to the group of buckwheat pseudo-cereals, that has different and identical characteristics like grains such as wheat, rice and barley [1]. Because of the main structural difference and ability to adapt to the development in a short time in highly agricultural areas, it is distinguished from other grains [2].

Buckwheat species are used as a food source [3]. Buckwheat is produced in many countries and has characteristics such as high economic value, easily consumable with versatile uses [4-7]. Because buckwheat is easy to adapt to ecology, it can be grown almost everywhere and in different habitats [8, 9]. Generally, buckwheat is grown in the northern hemisphere, Russia and China are the main producers. Also, its consumption is increasing in the United States, Canada and Europe [10]. In our country (Turkey), both for celiac disease and beekeeping sector are reported to continue agricultural activities with seeds imported from the United States [11].

Buckwheat is recognized as a good food source which is nutritionally valuable due to the content of protein, lipid, dietary fiber, and minerals, and in combination with other health-promoting components. Therefore, it has received increasing attention as a potential functional food. The amino acid composition and nutritional value of buckwheat are superior from other grains, also one of the protein sources having high biological value [5, 9, 12]. At the same time, buckwheat contains minerals such as zinc, copper, manganese, selenium, potassium, sodium, calcium and magnesium, also it contains vitamins such as B1, B2, B3 and B6; flavonoids, polyphenols, inositol, organic acid, and high dietary fiber [5, 13]. The compounds of buckwheat, which are common and tartary, is shown in Table 1 [14-16].

Buckwheat is used in many different culture products such as "stove", "kasha", "porridge", "erumpet", "naengmyeone" and "pizzoccheri" and to prepare cakes, bread, pasta, noodles, muffins, crackers, cookies, pancakes [8, 17, 18].

The aim of this review is to explain some positive effects of buckwheat on human health via studies in the literature.

2. BUCKWEATS’ POSITIVE EFFECTS ON HUMAN HEALTH

Buckwheat has many positive effects on health due to its rich and diverse nutritional content. It is thought that buckwheat may prevent genesis of diseases such as high cholesterol, hypertension, atherosclerosis and diabetes [9, 19, 20]. Rutin, high concentration in buckwheat, is also used for medical purposes in many countries in order to prevent or reduce capillary deformations that occur as a result of some hemorrhagic diseases and hypertension [21].

Foods, protecting against disease, improving disease condition and reducing disease risk, are defined as functional foods. This leads to a rise in the functional food consumption of consumers by increasing the availability of functional
Table 1. General composition of common and tartary buckwheat groats and sprouts.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Level (%)</th>
<th>Common Buckwheat</th>
<th>Tartary Buckwheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groats (Dry Matter)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starch</td>
<td>54.50</td>
<td>57.40</td>
<td></td>
</tr>
<tr>
<td>Soluble carbohydrates^a</td>
<td>1.60</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>7.0</td>
<td>10.60</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>12.30</td>
<td>13.15</td>
<td></td>
</tr>
<tr>
<td>Lipids</td>
<td>3.80</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>2.0</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td>Other compounds^b</td>
<td>18.40</td>
<td>10.53</td>
<td></td>
</tr>
<tr>
<td>Sprouts (Fresh Weight)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>92.80</td>
<td>92.34</td>
<td></td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>0.70</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>0.17</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Lipids</td>
<td>0.38</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>0.68</td>
<td>0.49</td>
<td></td>
</tr>
</tbody>
</table>

^a Including sucrose and fagopyritols. ^b Organic acids, phenolic compounds, tannins, phosphorylated sugars, nucleotides and nucleic acids, and unknown compounds.

The antioxidant properties of buckwheat were found to be due to the richness of the phenolic compound content in the in vitro studies [26-28]. Zielinski and Kozlowska (2000) in their study, identified the antioxidant capacity of some cereals as buckwheat>barley>oats> rye [29].

Buckwheat sprouts contain various flavonoids such as orientin, isoorientin, vitexin, isovitexin, rutin and quercetin, while Tartary buckwheat, which is another buckwheat species, contains only rutin [30]. High flavonoid content increases the antioxidant capacity of buckwheat [31]. Sprouted buckwheat also includes flavonoids as well as high levels of polyphenolic compounds. Due to the high flavonoid and polyphenol content of buckwheat, it is thought to have beneficial effects on human health by its antioxidant effect [32].

Considering the antioxidant content of buckwheat, common buckwheat (Fagopyrum esculentum Moench) and tartary buckwheat (Fagopyrum tataricum Gaertn.) are generally considered in terms of their general composition, functional components and antioxidant capacities. Buckwheat has important antioxidant functions such as high reducing power, free radical scavenging activity, superoxide anion clearing activity and ability to bind iron ions. Tartary buckwheat sprouts have higher reducing power, free radical sweeping activity and superoxide anion clearing activity than common buckwheat, with lower binding effects of iron ions than common buckwheat [33, 34]. Studies on liver cells have shown that buckwheat reduces intracellular peroxide production and cleans superoxide anions in the cell. It has been determined that Tartary buckwheat greatly reduces cellular oxidative stress due to quercetin [35].

Fig. (1). The effects of buckwheat on health.

foods in the market [5, 22]. Since buckwheat is used in many functional foods produced worldwide, buckwheat products are used as food and medicine [9, 21]. Positive effects of buckwheat on health are shown in Fig. (1).

2.1. Antioxidant Effect

The nutritions and functional properties of buckwheat in the science has been a guide to the studies planned to be conducted for exploring the antioxidant properties. In a study with 37 people, the antioxidant capacity of blood plasma samples was determined taken from healthy individuals who used to consume 1.5 g buckwheat per kilogram at once [23]. A similar result was also found in the study where consumption of 160 grams of buckwheat honey in a liter of water or black tea and buckwheat enriched bread consumption were observed [24, 25].
2.2. Hypocholesterolemic Effect

The use of buckwheat as a cholesterol-lowering functional food is becoming widespread [36]. Increasing cholesterol intake may increase oxidative stress and plasma cholesterol levels. This potential increase may contribute to the development of chronic diseases such as atherosclerosis by increasing the regulation of low-density lipoprotein and oxidized LDL [37]. In vivo and in vitro studies suggest that buckwheat can regulate cholesterol levels and it can prevent the development of cardiovascular diseases [20, 38].

In a study, the effects of protein in buckwheat on mice with hypercholesterolemia were examined. As a result of the study, buckwheat reduced protein plasma cholesterol levels more than other grains, reduced sterols absorbed from the intestines, increased the amount of sterol removed from the body and helped to regulate the activity of liver cells responsible for high cholesterol [20]. In another similar study, the effects of serum myeloperoxidase and cholesterol levels on the inflammatory markers of common buckwheat and Tartary buckwheat were investigated. The result of the study shows that both buckwheat species significantly decreased both total cholesterol and HDL cholesterol and decreased myeloperoxidase level [38].

In a similar study, the effects of buckwheat (tartary) on sterol carriers in cholesterol absorption and genetic expression of proteins were examined. The data obtained in the study showed that buckwheat reduces plasma total cholesterol, non-HDL lipoproteins and hepatic cholesterol concentrations. It has also been found that buckwheat increases sterol excretion and reduces the absorption of cholesterol from the intestines. Buckwheat is considered a hypocholesterolemic nutrient due to the effects of reducing cholesterol absorption in the intestine [36].

2.3. Hypotensive Effect

It is thought that buckwheat, which is a functional food due to its high rutin and quercetin content and being used in the production of some functional foods, may show antihypertensive effect by regulating the renin-angiotensin system due to its high polyphenol content. In addition, buckwheat sprouts have higher phenolic content and antioxidant activity than other sprouts of grains [39, 40].

Excess dietary salt intake is considered one of the most important factors contributing to the pathogenesis of hypertension. Regulation of the diet's salt content and dietary pattern play a critical role in the prevention and treatment of hypertension [41]. In a study, the effects of high-salt diets on the blood pressure of rats with hypertension were investigated. Rats were divided into two group as the control group and those consuming buckwheat. As a result of the study, it was found that high salt diet significantly increased blood pressure and serum Na⁺ levels in the control group. It was determined that buckwheat significantly reduced the blood pressure, decreased oxidative damage, and increased Na⁺/K⁺ ATPase [42]. Buckwheat has antihypertensive effects by reducing systolic blood pressure and oxidative stress in arterial endothelial cells [43, 44].

Another study conducted on hypertensive rats found that in rats, consumption of buckwheat sprout increased endogenous vasodilators such as bradykinin and nitric oxide, low blood pressure and high antioxidant capacity compared to rats consuming other cereals [39].

A similar study also aimed to investigate the immunoreactivity effects in rats on systolic blood pressure and aortic endothelial cells after 5 weeks of consumption of buckwheat. As a result of the study, buckwheat consumption decreased systolic blood pressure and oxidative stress by decreasing immunoreactivity in aortic endothelial cells [43].

2.4. Hypoglycemic Effect

The exploration of the beneficial properties of buckwheat on hypertension-lowering and hypercholesterolemia has led to focus on the effects of buckwheat on diabetes [45-47]. Diabetes is a chronic disease associated with inadequate insulin secretion or an increase in plasma glucose level resulting in ineffectiveness of insulin activity. The use of carbohydrate-containing foods according to glycemic index to control and treat diabetes was observed to have positive effects on the disease [48-50].

Buckwheat is used in dietary treatment of diabetes, in China [51]. In a study done by Skrabanja et al. (2001), 10 healthy individuals consumed boiled buckwheat grouts, 50% buckwheat flour enriched bread and white bread. As a result of the study, the postprandial plasma glucose and insulin production were lower in subjects consuming buckwheat products, especially buckwheat grouts, than those who consumed white wheat bread [52]. Su-Que et al. (2013) randomly selected 10 individuals with diabetes, consuming buckwheat bread, who were found to have a 51% lower plasma glucose level following 2 hours than consuming white bread [53].

Another issue is that buckwheat digestion in the body may be more difficult than wheat and legumes due to certain antinutritional factors such as polyphenols and enzyme inhibitors. The delay in digestion helps in regulating blood glucose level. Buckwheat consumption with a healthy diet positively affects insulin level and blood lipids [54]. In some countries such as Taiwan, buckwheat is used as a nutritional support in the treatment of type 2 diabetes. Rutin and quercetin in buckwheat, reduce insulin resistance through their ability to increase the activity of hepatic antioxidant enzymes [55]. In addition, it is suggested that the chemically synthesized D-chiro-inositol, an insulin regulatory component known to be antihyperglycemic agents, is used to lower serum glucose concentrations in diabetic patients and it is available relatively in high amount in buckwheat [56].

Buckwheat contains resistant starch [17]. Foods with resistant starch generally have a low glycemic index. Buckwheat can be used in the treatment of some chronic diseases because low glycemic index diets regulate blood glucose, prevent obesity and reduce heart disease risk [9, 57].

In a study conducted on adults who are healthy and have type 2 diabetes, participants were given foods made from white flour and buckwheat flour for one week. As a result, no changes were observed in glucose or insulin concentrations. However, a modulation of the gastrointestinal satiety hormones such as glucagon-like peptide-1 (potentiator of insulin secretion) and glucagon-dependent insulinotropic
peptide was documented after consumption of foods made of buckwheat flour in healthy and type 2 diabetic volunteers [58].

In a study conducted on type 2 diabetes patients, it aimed to investigate the effects of Tartary buckwheat supplementation to daily diet on increase of type 2 diabetes risk factors such as fasting blood glucose, insulin resistance and lipid profile. Participants were randomly divided into 2 groups as a control group and buckwheat consumption group. As a result of 4 weeks of diet and blood findings follow-up, it was observed that the group consuming buckwheat had a significant decrease in fasting insulin, total cholesterol and LDL cholesterol levels. In conclusion, it was determined that Tartary buckwheat had positive effects on insulin resistance and lipid profiles of type 2 diabetic patients [54]. In a study conducted on mice, buckwheat was found to reduce the increase in blood glucose and insulin levels resulting from high glucose and fructose diets [55].

In a study conducted on diabetic rats, it was determined that the consumption of buckwheat decreased serum glucose concentrations by 12-19% at the 90th and 120th minutes after consumption and was effective in lowering the increase in serum glucose [56].

In another study on rats, it was determined that buckwheat decreased the increase in blood glucose level after 60th minutes of oral sucrose consumption. In addition, it was observed that blood glucose levels of buckwheat-fed mice were significantly lower after 30th minutes of sucrose consumption [45].

In a study in which the hypoglycemic and hypolipidemic effects of flavonoids in Tartary buckwheat in type 2 diabetic rats were investigated, buckwheat consumption for 28 days resulted in a decrease in fasting blood glucose, serum insulin levels and body weight and improvement in glucose intolerance. In addition, a decrease in total cholesterol, triglyceride, LDL levels and increase in HDL levels were observed [59].

2.5. Neuroprotective Effect

Alzheimer's disease is associated with damage to cognitive and mental functions. Accumulation of amyloid beta peptides, Reactive Oxygen Species (ROS) and induction of inflammatory mediators such as nitric oxide, prostaglandin E2, interleukins and TNF-a are important neuropathological symptoms of Alzheimer's disease [60].

A study suggested that the consumption of buckwheat prevented the deterioration of neurological functions in animal studies. It was determined that 600 mg/kg buckwheat consumption for 21 days decreased the amount of nitric oxide by inhibiting glutamate release in the mice exposed to repetitive cerebral ischemia and improved memory disorders by preventing hippocampal cell necrosis and apoptosis [61]. Another study was carried out by the same researchers at an advanced stage, where buckwheat extraction was prepared and tested on hypokappal neuron cultures of mice. As a result, it was determined that this extraction showed the free radical scavenging effects of 2,2-diphenyl-1-pycrylhydrazyl (DPPH) and decreased cell damage induced by glutamate, kainite and β amyloid [62]. In an in vitro study, it has been found that ethyl acetate and ethanol extracts of root and buckwheat seed showed inhibitory effects on the formation of neurological disorders by playing roles such as antioxidant activity and enzyme inhibition including acetylcholinesterase, butyrylcholinesterase and tyrosinase [63].

In the literature, the number of studies examining the possible beneficial effects of buckwheat is limited. In an In vivo study model of the Alzheimer's disease in rats, it was determined that oral administration of methanol extract of Tartary buckwheat and the commonly used buckwheat to rats at 100 mg/kg for 14 days, resulted in the improvement of both cognitive and memory functions and in both types, decrease in lipid peroxidation and nitric oxide levels was observed. In addition, it has been found that Tartary buckwheat has a stronger protective activity than the commonly used buckwheat [64]. According to the studies in recent years, buckwheat has been stated to have shown inhibitory effects on neurological disorders, but responsible compounds for this effect are not completely explained [64-69]. Further studies are needed in this regard.

CONCLUSION

In conclusion, buckwheat is a food with rich nutrient content and important functional properties. In addition, it does not lose these properties in the processing stages, it also enriches the products it is added to both nutritionally and functionally. Because of these properties, it can show positive effects such as antioxidant, antihypertensive, anti diabetic on human health. Future in vivo and in vitro studies planned to be conducted should be designed to explain which compounds result in the observed positive effects by means of cellular and molecular mechanisms. In the direction of the findings obtained; the use of buckwheat on daily consumption should be extended in nutrition for chronic diseases and in order to prevent the occurrence of these diseases.

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

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