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Comprehensive review nutritional profile, and bioactive properties of buckwheat

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Abstract

Due to its distinctive characteristics from other grains, buckwheat has received interest for usage as a component in the creation of functional meals. The current review concentrates on buckwheat's physico-chemical characteristics, including its protein, fat, dietary fibre, and mineral content, and demonstrates how adding it to food improves the nutritional value. Additionally, buckwheat contains a variety of bioactive substances like flavonoids, phenolics like quercetin, vitexin, rutin, orientin, isoorientin, and isovitexin, steroids, and tannins that have anti-carcinogenic, anti-hemorrhagic, cardiovascular, antioxidant, anti-inflammatory, and blood vessel protective properties. The focus of this review is also on buckwheat's use as a functional food in a variety of sectors, such as agriculture, food, pharmaceuticals, and animal feed. Buckwheat is a beneficial ingredient for bread, rice, soup, cakes, noodles, cookies, and gluten-free beer due to its functional properties.

Keywords: Physico-chemical, anti-inflammatory, anti-hemorrhagic, pharmaceuticals

Introduction

Buckwheat: A pseudo cereal is a perennial member of the Polygonaceae family that is not related to grains, but it has traits that are both unique and similar to those of grains like wheat, rice, and barley (Yilmaz *et al.*, 2020) [24]. Buckwheat - nutritious food source because of it is rich in protein, fat, dietary fibre, and mineral content, as well as various bioactive compounds like flavonoids, phenolics including quercetin, rutin, orientin, vitexin, isovitexin, and isoorientin, steroids, tannins that support human health, thus this buckwheat has drawn more interest as one of the functional ingredients. Compared to other grain and pseudo cereal variety, buckwheat is rich in terms of amino acid content and nutritional value (Yilmaz *et al.*, 2020) [24]. Due to the rich and varied nutritional content of buckwheat, it has a number of beneficial impacts on health. It is believed that buckwheat may stop the development of disorders including diabetes, high cholesterol, hypertension, and atherosclerosis. A flavonoid called rutin has been shown to have antioxidant, anti-inflammatory, anti-carcinogenic, anti-hemorrhagic, cardiovascular, and blood vessel protection characteristics. (Podolska *et al.*, 2021) [13].

Buckwheat has been shown to have more potent antioxidant activity than other grains, owing to the presence of phenolics such as quercetin, rutin, orientin, vitexin, isovitexin, isoorientin, and catechins. Buckwheat's constituents have health benefits such as lowering blood pressure and controlling. It is also high in dietary fiber and starch protein, as well as nearly all vitamins, vital minerals, and trace elements. Blood sugar, lowering cholesterol, preventing fat accumulation, constipation, colon and mammary carcinogenesis, strengthening capillary blood vessels, and suppressing plasma cholesterol and gallstone formation. Buckwheat's gluten-free properties are another useful feature, making it a potential diet for celiac disease patients.

Because of their well-balanced amino acid content, buckwheat proteins have a high biological value. They are high in lysine and arginine, which are the first and second limiting amino acids in other plant proteins. However, glutamine and proline levels in Wheat is significantly lower, while threonine and methionine are the primary and second limiting amino acids, respectively. People who are deficient in thiamine may benefit from thiamine-binding proteins extracted from buckwheat (Krkoskova *et al.*, 2005) [8]. Furthermore, several researchers have shown that the low digestibility of Buckwheat proteins, as well as the rates of lysine/arginine and methionine/glycine, are important determinants in determining the plant protein's cholesterol-lowering benefits (Krkoskova *et al.*, 2005) [8].

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The supply of food and the production of agricultural by products are two of the European Union's food industry's most important roles (Giménez-Bastida *et al.*, 2015) ^[20-21]. Buckwheat is primarily used as a bread, rice, soup, cake, noodle, and cookie ingredient (Babu *et al.*, 2018) ^[3]. Additionally, buckwheat is used to make gluten-free beer. Other beverages that make use of buckwheat include buckwheat whiskey, buckwheat tea, and the Japanese buckwheat shochu. The staples of any bakery are cookies and biscuits. People of all ages love and eat a variety of nutritious food, especially children who need more protein than adults (Guo & Yao, 2006) ^[22]. These are perfect for making sure that vital nutrients are easily accessible.

Due to the rich and varied nutritional content of buckwheat, it has a number of beneficial impacts on health. It is believed that buckwheat may stop the development of disorders including diabetes, high cholesterol, hypertension, and atherosclerosis. The anti-inflammatory, anti-hemorrhagic, cardiovascular, antioxidant, and blood vessel protective properties of a flavonoid known as rutin have been demonstrated (Podolska *et al.*, 2021) ^[13].

Nutritional composition of buckwheat

Buckwheat is an excellent energy source and nutrients, making it a perfect alternative for non-vegetarian food. Buckwheat

contains a high percentage of protein, lipids, and micronutrient. Buckwheat has a relatively high protein level when in contrast to other grains including wheat, rice, maize, and sorghum. Buckwheat seeds have a protein content range from 8.51 to 18.57%. (J Gao *et al.*, 2016) ^[25]. Lipids are usually a minor component in cereals and pseudocereals, while having a significant physiological effect. Buckwheat grains contain between 1.5% to 4% of the total lipids. Carbohydrates make up the majority of the buckwheat grain's composition. Starch is the most common carbohydrate and is mostly located in the kernel endosperm. The availability of starch is influenced by its physical properties, its origin, the amylose-to-amylopectin ratio, and interactions with other substances (Przybylski & Gruczyńska, n.d.). Many scientists have looked at the nutritional functions of significant minerals found in buckwheat and foods prepared from it (Ikeda *et al.*, 2005a) ^[5]. The buckwheat seeds are full in vitamins like vitamin B1, vitamin B2, vitamin C, and vitamin E as well as nutrient-rich substances. The Tartary buckwheat type had 8.4% of dietary fibre, of which 8.2% was insoluble and 0.2% was soluble. TDF is present in bran without hull pieces at a concentration of 160 20 mg/g, but is soluble at a concentration of 750 mg/g. There are 400 mg/g of TDF in bran with hull fragments, of which 250 mg/g are SDF.

Table 1: Nutritional composition of Buckwheat

Nutrients	Composition (%)	References
Protein	8.51-18.57	(J Gao <i>et al.</i> , 2016) ^[25] .
Albumin	44	
Globulin	10	
Prolamin	8	
Glutelin	4	
Lipids	1.5-4	(Cai <i>et al.</i> , 2016) ^[4] .
Palmitic acid	14.8	
Oleic acid	36.5	
Linoleic acid	35.5	
Carbohydrates		(Nalin Kumar & Singh)
Starch	67-75	
Amylose	15-25	
Resistant starch	7-35	
Amylopectin	40-68	
Minerals		
Ash content	2.3-2.6	(J Gao <i>et al.</i> , 2016) ^[25] .
Zn, Cu, Mg & Mn	13-89	(V Skrabanja <i>et al.</i> , 2004) ^[26] .
Total dietary fiber	8.4	
Soluble fiber	0.2	(O Sytar <i>et al.</i> , 2018) ^[37] .
Insoluble fiber	8.2	
Vitamins		
A (carotenoids)	0.00021	(D Gabrovská <i>et al.</i> (2002) ^[27]
B1 (thiamine)	0.00046	(Bonafaccia <i>et al.</i> (2003) ^[32]
B2 (riboflavin)	0.00014	(Bonafaccia <i>et al.</i> (2003) ^[32]
B3 (niacin)	0.0018	(Kalinová <i>et al.</i> , 2002) ^[33]
B5 (pantothenic acid)	0.00105	(Gabrovská <i>et al.</i> , 2002) ^[2]
B6 (pyridoxine)	0.00073	(Bonafaccia <i>et al.</i> (2003) ^[32]
C (ascorbic acid)	0.005	(Raguindin <i>et al.</i> , 2021) ^[34]
E (tocopherols)	0.00546	(Giménez-Bastida <i>et al.</i> , 2015) ^[20, 21]

Bioactive components present in buckwheat

Buckwheat is one of the gluten-free crops that belongs to the Polygonaceae family with various functional and bio-active compound that gives us various health benefits. Till date, researchers have found different bio-active compounds from different parts (seed, flower, sprouts, leaves) of buckwheat

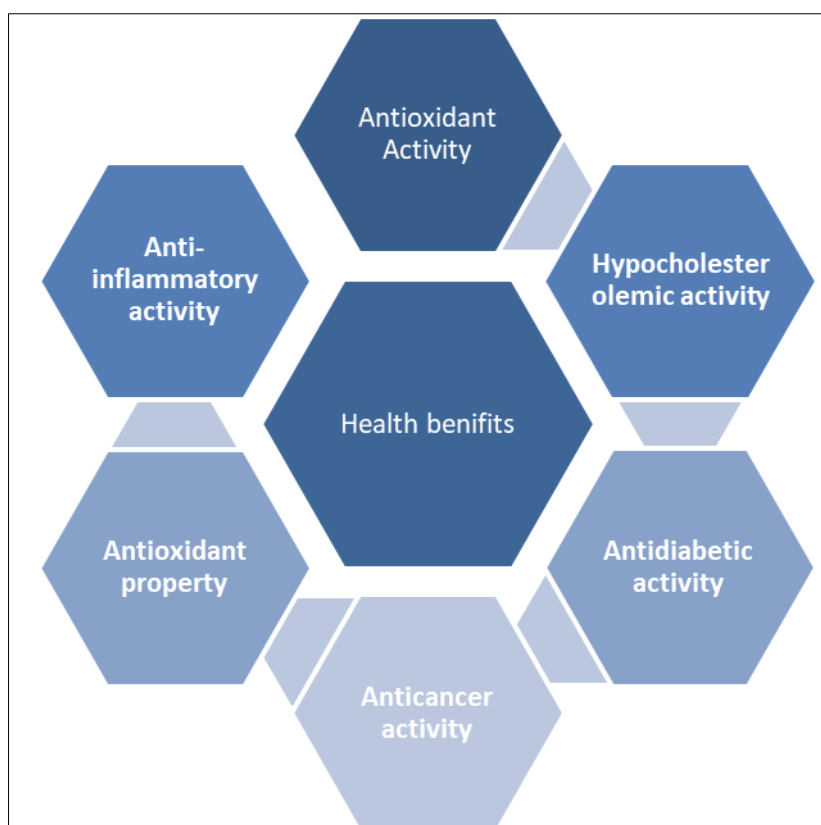
including phenolic compounds, flavonoids (flavonols, flavones, flavanones, Isoflavones) quinones, triterpenoids, steroids, glycosides, and many others. (Liu *et al.*, 2021) ^[35]. The predominant class of secondary metabolites with a minimum of one hydroxyl group, known as flavonoids, are found primarily in plants and foods (Górniak, *et al.*, 2019) ^[36].

Another significant subclass of flavonoids is called flavones. The seeds, leaves, sprouts, flowers, grains, and hulls of *Fagopyrum* species all contain flavones in varying amounts. In the *F. cymosum*, Common buckwheat sprouts include four flavones, orientin, isorientin, vitexin, and isovitexin identified. These flavones were also found in seeds, sprouts, and germinated seeds of Tartary and common buckwheat (Jing *et al.*, 2016) [6,15]. The main bioactive component of buckwheat is a flavonol. From numerous *Fagopyrum* species, several flavonols have been found. The primary flavonol in buckwheat, which makes up 90% of all phenolics, is rutin (Sytar *et al.*, 2018) [37]. Another form of flavonoid is fagopyrin, which is mostly found in low-density and challenging to extract buckwheat seeds. The phenolic acids, such as chlorogenic, caffeic, ferulic, gallic, phydroxybenzoic, protocatechuic, syringic, and p-coumaric acids, were isolated from each milled sample of Tartary buckwheat, including the hull, coarse bran, fine bran, and lightly flour (Yang *et al.*, 2019) [24].

Health benefits of buckwheat

BW's nutritional and useful benefits are now becoming better understood, which has sparked some research into its antioxidant capabilities. Human intervention studies appear to mirror the antioxidant properties of BW pseudocereals. Increased cholesterol intake can result in oxidative stress, raise blood cholesterol levels, and upregulate low density lipoproteins (LDL) and oxidised LDL (ox LDL), which can

accelerate the onset of chronic disorders including 21 atherosclerosis. BW may have a preventive impact against cardiovascular disorders due to its capacity to control cholesterol (Ch) levels, according to *in vitro* and in animal investigations. Diabetes is a chronic condition brought on by inadequate insulin production or inadequate insulin action, both of which raise plasma glucose levels. The anticancer action of BW has been linked to its antioxidant qualities since oxidative DNA damage is indicated in the genesis and promotion of cancer. More *in vitro* and *in vivo* investigations must be carried out to support the possible health promoting effects of BW and its constituent components, even though these results pave the way for new therapeutics for the treatment and prevention of malignancies like cancer. Finding substitute tests to these *in vitro* tests for uses involving humans has drawn growing attention (Tien, *et al.*, 2018) [30]. Obesity is the most ignored worldwide health issue since it is both serious and visible (Holasoava *et al.*, n.d.). A typical physiologic response to tissue damage, microbial infections, and chemical irritation is inflammation. Cognitive function impairment and mental disorder are both symptoms of Alzheimer's disease. Important neuropathological markers of Alzheimer disease include the accumulation of amyloid peptides, formation of reactive oxygen species (ROS), and activation of pro-inflammatory mediators such NO, PGE2, ILs, and TNF-. Animal experiments have shown that BW intake has neuroprotective effects.



Industrial applications of buckwheat

The functional components of buckwheat and its derived products have good benefits in preventing and controlling chronic diseases. In recent years, with the improvement of people's awareness of the nutritional and health value of bw

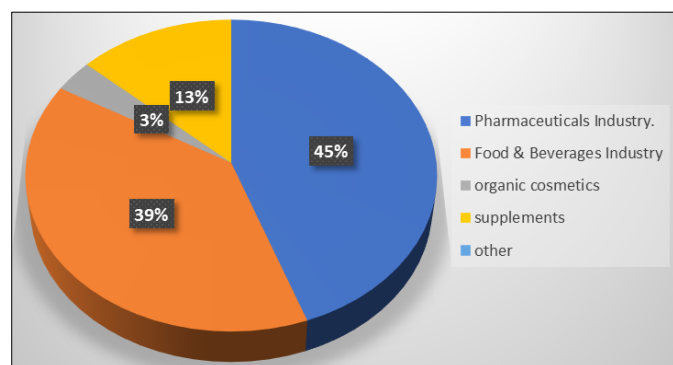
and the rapid development of modern food processing technology and equipment, the varieties of bw products are more abundant and diversified. Several healthy foods related to bw have been authorized by the State Administration for Market Regulation of China.

Table 2: Industries Products Application

Industries	Products	Application	References
Bakery industry	Cookies	Tender textures and darker shades to dishes cookies and bread add moistness to cakes Buckwheat noodles also have a delicious, slightly nutty taste,	(Giménez-Bastida <i>et al.</i> , 2015) [20-21]
	Noodles		
Beverage Industry	Non-alcoholic beverage	By using kernels made gluten free proteinous beverages and also balanced amino acid content	(Yilmaz <i>et al.</i> , 2020) [24]
	Alcoholic beverage	Used to increase immunity. Maintains gastrointestinal health. They have anticancer genic effects.	(Arendt & Zannini, 2013) [2]
Pharmaceuticals	Capsules	Improves blood flow by strenghtening veins and small blood vessels To prevent hardening of the arteries	(Chaturvedi <i>et al.</i> , 2022) [29]
	Tablets	Tablet as medicine to influence the permeability of the vesselsl helping to prevent haemorrhages and ruptures.	(Hagels <i>et al.</i> , 1995) [28]
Animal feeding	Poultry fodder	Common buckwheat has low protein concentration for poultry and pig nutrition	(Leiber, 2016) [9]

Global buckwheat Extract market application

The global buckwheat extract market is expected to grow due to increasing demand for natural and plant-based ingredients in the food, pharmaceutical, and cosmetic industries. Buckwheat extract has various applications in these industries, including:



Conclusion

Buckwheat has a lot of potential as a general food ingredient, especially for the functional and therapeutic food sectors. Pseudo cereal buckwheat is rich in nutrients like high-quality protein, dietary fibre, rutin, resistant starch, vitamins, and minerals. The actual impact of buckwheat and its products on people should be the subject of greater research, in general. Rats responded favorably to most research on the effects of resistant starch, buckwheat protein product and flavonoids. Fagopyritols and D-chiro-inositol decreased the level of plasma glucose in rats, suggesting its potential role in the treatment of diabetes. According to several reports, buckwheat protein products have been shown to offer a variety of useful qualities in rats, including hypocholesterolemic activity in animals given. For people with celiac disease, buckwheat is a staple in their daily diet. Similar to cereals, there is a presence of starch. Although buckwheat starch is comparable to cereals in shape and composition, it more closely resembles tuber starches in terms of other characteristics, such as high viscosity values. While the hulls of buckwheat contain the most fibre, dehulled groats (seeds) have comparable insoluble fiber to other cereals. The buckwheat protein is of an excellent nutritional grade since it has a comparatively higher lysine level than other grains.

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