



An Overview of Buckwheat (*Fagopyrum* spp)-An Underutilized Crop in India-Nutritional Value and Health Benefits

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ABSTRACT

Buckwheat is one of the pseudocereals grown annually in hilly regions of India. It belongs to the family Polygonaceae and genus (*Fagopyrum* spp.) Buckwheat is adaptable to extreme cold temperatures, stress conditions of water, less soil fertility and varying climatic conditions, making it a sustainable crop. A literature search on Buckwheat was done using PubMed and Google search engines and reviewed to prepare an overview of its cultivation, nutritional and health value. In India, twenty species of Buckwheat are cultivated across various hilly regions. Out of these only nine species have desirable nutritional value and two are commonly grown. They are *Fagopyrum esculentum* Moench (Common buckwheat) and *Fagopyrum tataricum* (Tartary buckwheat). However, the cultivation of Buckwheat has declined in the 20th century making it an underutilized crop. Buckwheat has good amount of nutrients and many health benefits. There is a need to research about this under-utilized crop and create awareness as this crop has many nutritional and health benefits.

Keywords: Gluten, Pseudocereals, Flavonoids, Rutin, Diabetes, Hypertension, Anti-carcinogenic

Key Messages: Buckwheat is a pseudocereal grown annually in hilly regions of India. Its cultivation has declined in the 20th century making it an underutilized crop. Hence there is a need to research about this crop and create awareness to increase utilization

INTRODUCTION

Buckwheat is one of the pseudocereals and minor cereals grown annually in hilly regions of India. Pseudocereals are not true cereals. Botanically cereals are monocotyledonous plants, whereas pseudocereals are dicotyledonous. Pseudocereals belong to the category of plants that produce both edible fruit and seed. Pseudocereals do not belong to grass family of plants, but they are considered under cereals due to their similar chemical composition. The other pseudocereals are Amaranth and Quinoa. Buckwheat belongs to the family Polygonaceae and genus (*Fagopyrum* spp.) [1]. In the present scenario of climate change and ever expanding population in the hilly areas, Buckwheat has the capacity to meet the increasing food demands in these regions. It grows in higher altitudes for a short duration of growth pattern within 3-4 months and thus it is the best growing crop in such areas [2]. Buckwheat is adaptable to extreme cold, lack of water, less soil fertility and varying climatic conditions [3,4]. Due to its adaptability to marginal as well as infertile lands of the hilly areas, it is considered as a sustainable pseudocereal, as it supports the livelihood of millions of people residing in hill regions by increased production due to improved yield in short period [2,5].

METHODS

Search Methods

A literature search on Buckwheat was done using PubMed and Google search engines and reviewed to prepare an overview of its cultivation, nutritional and health value. Search terms "Buckwheat" in combination with "cultivation", "Nutritional value" and "Health Benefits" were used. Relevant cross references for previous studies about nutritional value of other cereals was also reviewed.

Cultivation of Buckwheat

Buckwheat is among the various ancient cultivated crops of Asia and is mainly cultivated in India, China, Nepal, Canada, North Korea, Bhutan, eastern Russia, Mongolia and Japan. However, in the first half of 20th Century, the production of Buckwheat has declined [6]. The average Buckwheat production in the world in 2018 was 2.9 million tones which have been declining when compared over the past three years [7].

In India, Buckwheat is grown majorly in hill areas of Jammu and Kashmir (Udhampur, Ladakh, Kargil and Drass sectors, Gurez valley), Uttarakhand, Himachal Pradesh (Bharmaur, Pangi, Kulu, Shimla, Kinnaur, outer Saraj, Chopal, Dodra kaur, Neshang, Pooh division, Lahaul valley, Pin valley), Chattisgarh, Uttar Pradesh (Uttar kasha, Chamoli, Pauri, Almora and Pithoragarh), West Bengal (regions of Darjeeling, Kalimpong, New Jalpaiguri and Coochbehar), Upper Assam region, Sikkim (Lachan and Lachoong), Meghalaya, Manipur, Arunachal Pradesh (Tawang, Bomdilla and Dirang), Nilgiris and Palani hills of Tamil Nadu, and Kerala [5,8]. There is a decline in the cultivation and production of Buckwheat due to changing patterns of land use in India [5].

In India, there are twenty species of Buckwheat cultivated across various hilly regions, out of these only nine species have desirable nutritional value and two are commonly grown. The commonly grown and consumed buckwheat species are *Fagopyrum esculentum* Moench (Common buckwheat) and *Fagopyrum tataricum* (Tartary buckwheat). In Asia, Tartary buckwheat is widely grown whereas Common Buckwheat grows widely in Unites States, Europe and Asia [9]. In India, both the common buckwheat and Tartary buckwheat are grown in different levels of altitude, common buckwheat in lower altitudes upto 1000 m and the other in higher altitudes >2500 m².

Nutritional Value

Buckwheat has a good amount of nutrients as compared to the other cereals and has excellent sources of macronutrients, micronutrients and bioactive compounds [10]. The Nutritive value of Buckwheat in comparison with most commonly consumed crops in India is given in Table 1 [11,12].

Table 1 Comparison of nutritive value (%) of buckwheat with other cereals and millets in India

Source	Common Buckwheat	Tartary Buckwheat	Wheat, whole	Rice, milled	Barley	Maize, dry	Jowa ^a	Ragi ^b	Varag ^c	Bajra ^d
Energy	343	328	322	356	316	334	334	321	332	348
Carbohydrates	71.5	74.3	64.7	78.2	61	65	67.7	66.8	66.2	61.8
Protein	13.3	10.3	10.6	7.9	10.9	8.8	10	7.2	8.9	11
Lipids	3.4	2.5	1.5	0.5	1.3	3.8	1.7	1.9	2.5	5.4
Dietary Fibre	10	6.3	11.2	2.8	15.6	12.2	10.2	11.2	6.4	11.5
Ash	2.1	1.8	1.4	0.6	1	1.2	1.4	2	1.7	1.4
Moisture	9.8	10.2	10.6	9.9	9.7	9.3	9	10.9	14.2	9

Source: Adapted from Przybylski and Gruczynska [11] and Indian Food Composition Table [12]; ^aJowar (*Sorghum vulgare*); ^bRagi (*Eleusine coracana*); ^cVaragu (*Setaria Italica*); ^dBajra (*Pennisetum typhoideum*)

Starch: Starch is the major component of Buckwheat ranges from 59%-69% of the grain composition, with 15-25% of amylose and 7%-35% resistant starch and the remaining proportion is Amylopectin [13]. The starch content of Buckwheat varies based on extraction method and variety of cultivars, hence it varies from 59% to 70% of dry matter [14].

The chemical composition of Buckwheat shows that Amylose content may vary between 15-52% containing almost 12-45 glucose subunits in its chain which depends on extent of polymerization. Apart from the amylose content, Buckwheat also contains 0.65% to 0.76% of reducing sugars, 0.79% to 1.16% of oligosaccharides and 0.1%-0.2% of long chain polysaccharides [14]. The amylose content of Buckwheat flour was 18.48% and in another study the amylose content of Buckwheat flour was between 19%-28% [13,15].

Protein: Protein content in Buckwheat ranges from 11%-14% with a balanced proportion of all the essential amino acids [2]. It is seen in Table 1 that Common Buckwheat has the highest amount of protein when compared to other

cereals. Studies show that the protein content of buckwheat depends on its cultivar and other ecological factors during its growth, thus the concentration of protein in common buckwheat ranges from 7%-21%. However the seeds of Buckwheat as a whole have a protein composition of 11%-15% of most commonly grown species [14].

Buckwheat is rich in lysine, arginine and aspartic acid [10]. The quality of buckwheat protein is highly digestible and has 80% digestibility coefficient, mainly due to rich concentration of amino acids such as lysine (5.5%-6%), threonine, arginine (9.2%-10%), tryptophan and sulphur containing amino acids [2,16,17]. Some studies showed that digestibility coefficient of buckwheat is low due to high fiber content [14]. Cereals are deficient in Lysine and needs to be complemented with pulses to give a balanced proportion of all the essential amino acid [18]. However this is different in case of Buckwheat which is rich in lysine and makes it unique among all the cereals [10].

The form of proteins in Buckwheat is Globulins, which forms the major proportion, followed by albumin and prolamins. Globulin in Buckwheat contains 12-13 subunits and they have a variable molecular weights between 17000-57000, whereas albumin in Buckwheat has 12 subunits with molecular weight between 7000-8000 [14]. Buckwheat has a high biological value protein [19]. The biological value of Buckwheat protein is higher when compared to wheat, barley, rye and oats [14].

Lipids: The total lipid content of Buckwheat ranges from 1.5%-3.7%, with embryo comprising the highest proportion of 7%-14% and hull comprising the lowest proportion of 0.4%-0.9% [14]. The major amount of fatty acids in Buckwheat is 95% of Palmitic, Oleic and Linoleic acid [2]. Buckwheat contains palmitic acid, oleic acid, linoleic acid, linolenic acid, arachidonic acid, stearic acid, Behenic and Lignoceric acid, whereas the latter three comprise 8% of total fatty acids [14].

Vitamins and minerals: Buckwheat is rich in minerals especially Calcium, Magnesium, Potassium, Phosphorous, Iron, Manganese, Selenium, Copper and Zinc [2]. Additionally, it also contains a good concentration of Thiamine, Riboflavin, Niacin, Pantothenic acid, Pyridoxin, folate and ascorbic acid [14].

Flavonoids: Flavonoids are the secondary metabolites and naturally occurring antioxidants in the food which have physiological health benefits [20]. The major flavonoid present in Buckwheat is Rutin, also called as Vitamin P, which is present in a higher concentration in Tartary Buckwheat as compared to the Common Buckwheat. The other flavonoids in Buckwheat are quercetin, vitexin, orientin, isovitexin and isoorientin. The content of flavonoid depends on various factors such as the difference in growth factors of seed, testa, size and shape of the seed, color of the flower, and time of sowing, soil location, environmental fluctuations, climate changes, growth stages and area of collection [10]. Rutin content also varies and depends on the genotype of Buckwheat and ranges about 3%-6% of dry weight in foliage of Buckwheat [2]. Buckwheat contains higher proportion of rutin than quercetin [21]. The concentration of Rutin in Tartary Buckwheat is 100 fold is higher than that of common Buckwheat and Tartary wheat contains 3 bitter compounds among which one is quercetin and the other two are unidentified [22]. Buckwheat is the only cereal that has rutin and thus forms a good source of rutin in the diet. Additionally, Buckwheat also has tannins which affect the nutrient absorption and these provide astringency and affect colour along with the phenolic compounds [14].

Fagopyrin: A naphthodianthrone substance in Buckwheat is Fagopyrin that cause sensitivity to light after ingestion [2]. Fagopyrin is mainly found in the fresh green parts of the plant, which are consumed as a vegetable in form of sprouts, thus its recommended intake of it is limited to 40g/day based on hypericin toxicity [23].

DISCUSSION

Health Benefits

Buckwheat has its unique nutrient composition that includes lysine rich protein, dietary fibre, mineral and trace elements, antioxidant rich vitamins and bioactive compounds such as rutin, quercetin and other flavonoids [2,14,24,25]

Rutin has strong anti-oxidant [26,27], anti-inflammatory, anti-hypertensive properties which are beneficial in cardiovascular diseases [28], thus its demand is increasing in the industries, pharmaceutical industries and cosmetic industries [2,5,20]

Rutin, a flavonoid present in Buckwheat helps to prevent oedema, coronary artery disease [28], haemorrhagic disorders, and controlling hypertension, and also has anti-carcinogenic properties [2,29]

Slow digesting ability of carbohydrates has a better response on the Glycaemic control by maintaining the plasma glucose levels post absorption improving the secretion and sensitivity of insulin [30]. Buckwheat has a complex starch molecule consisting of complex carbohydrates that digest slowly after consumption and has a slow releasing capability [31]. This property of carbohydrate is useful in controlling the sugar levels of the blood, thus buckwheat is a good diabetic food for the people having Diabetes [2]

Research evidence shows that Gluten in foods is the most causative factor of Celiac Disease, as gluten intake in predisposed individuals of this disease triggers the immune system's response and may aggravate the condition [32]. Buckwheat is devoid of gluten and is helpful in the diet for the people with celiac disease [10,33,34]

Tea made from Tartary Buckwheat is beneficial in lowering the blood glucose levels and serum lipids levels 2. Buckwheat tea is also rich in flavonoids [35]

Culinary Uses

Buckwheat has culinary uses in India. Buckwheat plant produces tender leaves that are used as for making accompaniments like leafy chutneys and a vegetable curry. Buckwheat plant nectar produces a good amount of honey particularly around the sunrise. The seeds of Buckwheat are used for popping and consumed as a popped food in India [2]. The flour from buckwheat is commonly called as Kuttu ka atta in the northern part of India which is mainly used during the fasting occasions in some festivals and also for devotional purposes. Buckwheat flour is also used in preparation of bakery items, traditional breads, pancakes, etc. [2,5] Some alcoholic beverages are prepared by fermentation process by using some cereals like barley majorly, however Tartary wheat is also used for such preparations in India [2]. Buckwheat leaves are also used to prepare tea [9,36].

Prospects and Scope of Buckwheat in India

With respect to cultivation, Buckwheat has a greater scope as it requires a short period to grow and is able to sustain in any climatic environmental stress situation. Further, it has a strong growth potential which requires minimal resources and can grow in poor and marginal soils.

Buckwheat has been a source of livelihood for the farmers and people residing in hilly areas, but its cultivation is decreasing due to the decline in interest of farmers. The attention of farmers is diverting towards extra income and profits arising from other cereals that are widely consumed in India. The interests of farmers are declining to practice agriculture in hilly regions. Green revolution has brought changes in the genetic diversity in the agriculture field. It has lead to the adoption and technological interventions for the cultivation of high demanding crops in India. The growing population, economic stability, food security of the country is highly dependent on some major utilized crops like wheat, maize and rice. Thus there is a need to research this under-utilized crop and create awareness as this crop has many nutritional and health benefits.

Due to its various health benefits that arise from presence of a distinct group of nutrients such as protein, dietary fibre, vitamins, minerals and bioactive compounds, it can be a super food for population at risk for various non-communicable health disorders or metabolic disorders. It forms a good source of protein with balance of all essential amino acids for the vegetarian and non-vegetarian group of population.

CONCLUSION

The advocacy of Buckwheat in India is not widely spread all over the country. Many segments of population in the country are unaware of the crop, thus it is being under-utilized and therefore decline in demand and production. Thus there is a strong need for awareness regarding its nutritional and health benefits. Many scientific interventions are needed to increase production and utilization of Buckwheat.

DECLARATIONS

Acknowledgement

I would like to express my deepest sense of gratitude to Professor Dr. Sushma Batra, Department of Social Work, University of Delhi, India, for her constant support and valuable guidance. I wish to acknowledge Pankti Motani, Research Consultant, Cuddles Foundation, who with her vast experience and inspiring thoughts has encouraged me to

complete this study. I extend my humble sense of gratitude towards my family who provided a source of inspiration.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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