Comprehensive Review of Pseudocereals with Low Glycaemic Index Value and Their Utilization in The Development of Functional Food Products

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Abstract

The present review explores a comprehensive study focussing on pseudocereal and their lower glycaemic index values. The utilization of coarse cereals such as buckwheat, amaranth, finger millet, and sorghum have low glycaemic index values with multifaceted health-beneficial components comparatively higher than other grains. The key elements include dietary fibers, which are considered the most crucial factor for reducing the glycaemic index of the food. Each coarse cereals are reported to have different bioactive compounds such as flavonoids, saponins, polyphenols, vitamins, and minerals and is reported to show potential to lower cholesterol levels and induce wound-healing activity, anti-diabetic, anti-inflammatory, cytoprotective, anti-bacterial, and anti-cancerous properties. Furthermore, functional foods with low glycaemic index are also being devoured by individuals with obesity due to their rich secondary metabolic profile, they show superiority to other cereals because of their nutritional qualities including being protein-rich, essential amino acids, phenolic compounds, and antioxidants. Low glycaemic index coarse grains have appeared as great candidates as functional foods in this chapter.

1. Introduction

The glycaemic index (GI) is a metric of ranking per gram of carbohydrate by its glycaemic potential. It is a measure of determining the effect of foods on the blood sugar levels of an individual. GI is determined *in vivo* by feeding a subject with the reference food and measuring blood glucose levels at an interval over a period of 2-3 hr. Tracking the GI values of food allows individuals to mitigate diabetes and make healthier food choices.

Brand-Miller and Foster-Powell (1999) at the University of Sydney classified foods as low, medium, or high glycaemic using the GI ranges based on the glucose reference i.e. low (55 or less), medium (56–69), and high (70 or more). Low-carbohydrate foods may not contain enough levels of sugars and starches that would raise blood glucose levels when eaten alone. However, several low-carbohydrate foods consumed together as a meal may cause some postprandial glycemia. Studies performed in the last decade have identified a low-GI diet as beneficial concerning metabolic syndrome.

Modern lifestyles, rise in per capita income, and bad eating habits have resulted in a tremendous increase in chronic diseases such as obesity, high blood pressure, cardiovascular diseases, and diabetes. Diabetes is a metabolic disorder characterized by high glucose or above-normal glucose levels (70–100 mg/dL) symptomatically with frequent urination, thirst, and hunger. The main causes are either less production of insulin by β-cells or reduced cell response to insulin. It is a leading non-communicable disease with multiple aetiologies, affecting more than 100 million people worldwide, and is considered one of the ten leading causes of death in 2021 in the world. Epidemiologic data indicated that 2.8 percent of the world's population was diabetic in the year 2000 and it is expected to progress to 4.4 percent of the world's population by 2030. It affects all age groups of people and ethnic groups. The steepest rise will take place in the regions dominated by developing economies. It has been estimated that the total number of people with diabetes in India in 2019 was around 77 million, which is expected to rise to 134 million by 2045. Diabetes can be categorized into different types such as type 1 diabetes, type 2 diabetes, gestational diabetes, and others. Two major types taken into account are Type-1 diabetes, where beta cells fail to produce enough insulin for the body, and Type-2 diabetes which is influenced by the lifestyle changes of an individual such as physical inactivity, obesity, and thus body doesn't form sufficient insulin.

Obesity is another major health issue worldwide and the fifth-most common reason for mortality globally. According to WHO, it is the "abnormal or excessive fat accumulation". In simple words, it is the energy imbalance of both calories consumed, and calories expended. (BMI) Body Mass Index is measured to categorize an adult into underweight, overweight, and obese. It is a relation between the body weight of an adult to his height, confirming whether an individual has a healthy weight or not. This is calculated using a simple formula [weight in *kg*/height in m^2]. The classification is shown in the given Table 1.

Table 1: Showing the categorization of an individual based on BMI

Categorization	BMI (kg/m^2)	Risks of co-current illness
Underweight	<18.5	Slight chances
Normal weight	18.5-25.0	Low risk
Overweight	25.0-30.0	Slightly increased
Obese	>30	
Obese I	30.0-34.9	Mild
Obese II	35.9-39.9	Acute
Obese III	>40	Very acute

Pseudocereals refer to a group of plants that produce seeds that are consumed as grains. The word is comprised of two words 'pseudo' means false or assembling and cereals. They are abundant in roughage, protein, vitamins, and minerals and exhibit health-promoting effects such as anti-cancerous, anti-diabetic, lower cardiovascular diseases, and oxidative stress as phenolic compounds are present. The glycaemic index has a range scale of 100 based upon the impact of carbohydrates on blood sugar levels such as for low (<55), medium (55-70), and high (>70). It is discovered that the GI of pseudocereals lies in the range of low GI category including amaranth (47.65), buckwheat (52.35), and quinoa (61.50). Commercialization of pseudocereals as functional foods can cater to numerous health problems and at the same time provide vital nutrients for living a healthy life. The term "Functional Food" appears as a generic descriptor of the benefits that follow eating meals that go beyond those accounted for solely by the nutrients delivered. In simple terminology, functional foods are the components that provide health benefits beyond basic nutrition. Reformulation of bakery products and others with pseudocereals can be a good option as they are known for gluten-free grains having high nutritional value such as minerals, vitamins, proteins, starch, and phytochemicals (predominant phenolics).

2. Nutritional composition of pseudocereals

Pseudocereals belonged to non-grass plants that produce nutrient-rich seeds possessing a similar structure as cereals including endosperm, testa, hull, and aleurone. They are an excellent source of bioactive compounds such as lignans, flavonoids, phytosterols, fatty acids, dietary fibers, betalins, high-quality amino acids, and other macronutrients. Despite this, they are rich in folate, calcium, potassium, lutein, vitamin A, and B6. The nutritional composition of pseudocereal is shown in Figure 1.

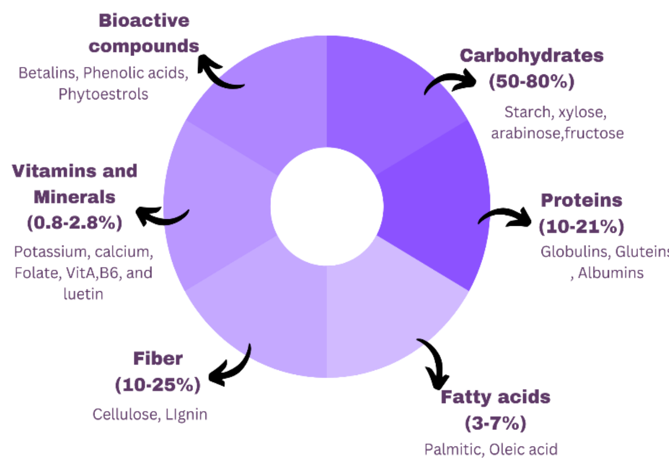

Fig. 1. The nutritional composition of pseudocereal

3. Bioactive Compounds

The components that contribute to the health-promoting effects of pseudocereals are the presence of bioactive compounds such as flavonoids, phenolic compounds, betalains, and phytosterols.

Flavonoids are a group of compounds that have antioxidant properties that lower oxidative stress and protect against memory dysfunction. Pseudocereals like quinoa are rich in flavonols including quercetin glycosides, and kaempferol while in tartary buckwheat four major flavones are found such as orientin, isoorientin, orientin, and vitexin. AGEs are toxic end products formed when end products are exposed to high temperatures and are also being suppressed by rutin found in amaranth.

Phenolic compounds represent a rather heterogeneous group of secondary metabolites. Phenolic acids are mainly gallic acid, whereas others involved p-hydroxybenzoic acid, vanillic acid, p-coumaric acid, and cinnamic acid. Amaranth also contains a wide range of phenolic acids, among which ferulic acid is very important because of its antioxidative activity and significance in the context of dietary fiber whereas tartary buckwheat contains phenolic acids, including gallic acid, p-hydroxybenzoic acid, and vanillic acid.

Betalains are part of the Amaranthaceae family, such as those found in amaranth and quinoa. Among these compounds are betacyanins and betaxanthins which have antioxidant, anticancer, antilipidemic, and antimicrobial properties. They are the compounds responsible for red-violet and yellow pigments in plants and therefore hold potential as natural food and pharmaceutical colorants.

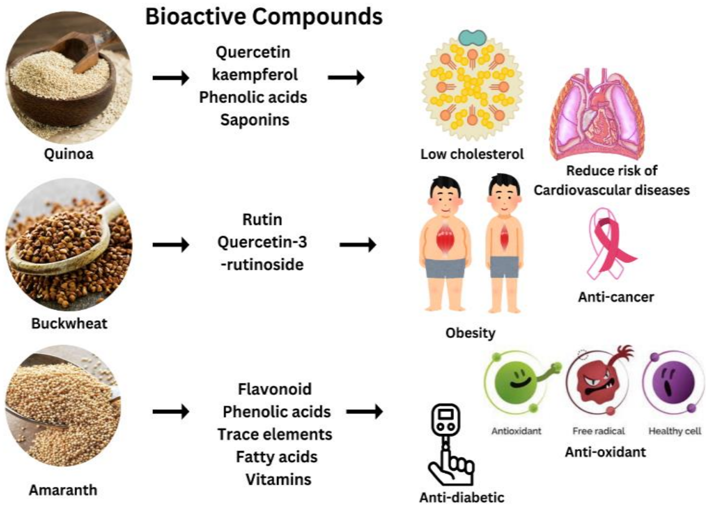

Fig. 2. Potential therapeutic effects of bioactive compounds

Physiochemical properties of pseudo-cereals

Buckwheat

Buckwheat (*Fagopyrum esculentum*) is a traditional crop in Asia and Central and Eastern Europe. Over the last 40 years, China has been the largest producer of buckwheat. Compared to most fruits, vegetables, and grain crops, buckwheat contains more rutin, which is a quercetin-3-rutinoside with antioxidant, anti-inflammatory and anti-carcinogenic effects and can also reduce the fragility of

blood vessels related to hemorrhagic disease and hypertension in humans. Rutin and isovitexin are the only reported flavonoids of buckwheat seed. Buckwheat hulls contain rutin, orientin, vitexin, quercetin, isovitexin and isoorientinm. The total flavonoids concentration of buckwheat seed is 18.8 mg/ 100 g and hull are 74 mg/ 100 g. The grains of buckwheat contain 11.8 per cent moisture, 54.5 per cent starch, 12.3 per cent protein, 7.0 per cent dietary fibre, 3.8 per cent lipids, 2.4 per cent minerals, 1.6 per cent soluble carbohydrates and 18.4 per cent other compounds. Bonafaccia et al. (2003) reported a dietary fibre of 27.38 per cent in buckwheat seeds, 12.5 per cent albumin, 8.0 per cent glutelin, and 2.9 per cent prolamins. Similar ranges have been reported by Radovic et al. (1999).

Amaranth

The grains of *Amaranthus* species are native to the New World. Pre-Columbian civilization grew thousands of hectares of this pseudo-cereal. Amaranth grain contains (5-11%) oil, which is found mostly within the germ. It is predominantly unsaturated oil (76%) and is high in linoleic acid, which is necessary for human nutrition. Due to the fact that grain amaranth has high protein, as well as a high fat content, there is the potential to use it as an energy food. Using milled and toasted amaranth products, digestion and absorption was found to be high in human feeding studies. The amaranth has a diverse range of species, with *Amaranth caudatus*, *Amaranth hypochodriacus* and *Amaranth cruentus* being the most often cultivated. Amaranth also contains a variety of chemicals, including as flavonoids, phenolic acids, trace elements, fatty acids, and vitamins, that have been shown to have beneficial effects on human health, such as the prevention and mitigation of a variety of degenerative disorders.

Table 2 Bio active compounds of coarse cereals and their effect on health

Sr. No	Coarse cereals	Bioactive compound	Health benefits
1	Buckwheat	Rutin, quercetin-3-rutinoside,	Antioxidant, anti-inflammatory and anti-carcinogenic, hemorrhagic disease, hypertension
2	Amaranth	Flavonoids, phenolic acids, trace elements, fatty acids, and vitamins	Prevention and mitigation of a variety of degenerative disorders
3	Quinoa	flavonoids such as quercetin, kaempferol, phenolic acids, saponins, and phytosterols.	Enhancing antioxidants, anti-inflammatory, cardioprotective effects and anti-cancer.

Quiona

Quinoa, a pseudo cereal which is known to have multiple nutritional attributes and health benefits. The grain retains good amounts of macronutrients in the form of about 11–19% proteins, 49–68% carbohydrates, and 2–9.5% fat. Moreover, quinoa is very well known for containing a higher percentage content of fiber ranging within 7.0–9.7% with excellent amino acid composition, particularly in lysine, which forms a highly deficient nutrient in cereal grains. Quinoa is a good source of other nutrients like magnesium, iron, and vitamin E. Though quinoa is endowed with the most basic nutritional elements, its bioactivity profile is enriched by an array of constituents including flavonoids such as quercetin, kaempferol, phenolic acids, saponins, and phytosterols capable of enhancing antioxidant, anti-inflammatory, and cardioprotective effects. This has been associated with reduced risks for a wide range of chronic diseases such as cardiovascular disease, type 2 diabetes, and cancer. Incorporation of Quinoa can be done in both conventional and functional foods in which it could be found both in gluten-free products, nutritional bars, and fermented products.

Conclusions

The present review reports the potential nutritional and functional properties of the pseudo-cereals, especially the possible low-glycaemic index foods such as buckwheat, amaranth, and quinoa. Pseudo-cereals are not only nutritionally rich; they contain huge amounts of bioactive compounds, such as flavonoids, phenolic acids, betalains, and dietary fibers, with diverse health benefits. These include metabolic disorders such as diabetes and obesity, cardiovascular diseases, and certain cancers. Their bioactive compounds exhibit antioxidant and anti-inflammatory properties alongside having the slightest anti-carcinogenic activity, thus contributing to reduced oxidative stress coupled with an improvement in general health. The exploitation of pseudo-cereals for functional foods is thus a promising strategy of facing the rising global health challenges caused by lifestyle-related diseases. Further research should focus on developing pseudocereal-based functional foods and their commercialisation and researching applications in other diets that can be helpful in better food choices and mitigation of the burdens that chronic diseases bring about all over the world.

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