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Chapter

Nutritional Composition of Grain and Seed Proteins

Adeola Abiola Oso and Anofi Omotayo Ashafa

Abstract

Grains including wheat, brown rice, millet, oat, and seeds from crops such as pumpkins, almonds, cashew, peas are important staple foods in many parts of the world. Grains and seeds contain proteins and bioactive peptides classified as nutraceuticals. Proteins and peptides are essential components in man’s diet because they provide the raw materials needed for protein biosynthesis and are also a good source of energy. Incorporating grains and seeds into the human diet provide nutritional, functional health benefits, reducing contracting some chronic diseases. They avail the body with a balanced nutrient profile such as carbohydrate, fatty-acid, fibre, B vitamins, minerals and protein. The quest at exploring staples for their functional and health benefits, as well as reducing risks to diseases, has resulted in the investigation of the potentials of grains and seeds, especially the underutilised ones (African yam bean, pigeon pea, Bambara groundnut etc.) for consumption and as an alternative therapy against diseases. This chapter discusses grains and seeds as sources of nutrition protagonist, their nutritive property, health benefits, and the pharmacological properties of bioactive peptides in grains and seeds. However, some under-utilised grain and seed proteins would also be explored for their nutritive potentials.

Keywords: bioactive peptides, grain, nutraceutical, protein biosynthesis, and seed

1. Introduction

Seventy-five per cent of the people in developing countries live in rural areas, especially sub-Saharan Africa and southern Asia [1, 2]. Despite intensification associated with the green revolution and expansion in agricultural production, many people remain food insecure, suffering from hidden hunger caused by protein deficiencies [3, 4]. The malnutrition problems could be addressed by exploring plant proteins as an economical and sustainable source of protein for a wholesome diet [5]. Grains and seeds are plant products containing proteins and peptides that can be classified as nutraceuticals. Nutraceuticals are any functional food extract with health and medical benefits, particularly to humans [6]. Grain and seed proteins are critical components in food systems that help combat protein-calorie malnutrition in developing countries [7]. They are referred to as the poor man’s meat of the vast majority who cannot afford fish, meat and dairy since they provide nutritionally balanced protein diets [8]. Grain and seed proteins create windows of opportunities by reducing poverty level, improvement in nutrition and health status, improvement in food security and sustenance of natural resource base among
Grain and Seed Proteins Functionality

Grain and seed proteins are a staple source of calories, carbohydrate, minerals, B-vitamins and proteins. Proteins from grains and seeds are probable sources of a wide range of bioactive peptides that positively impact man’s health [9]. Grain and seed high in protein include wheat, brown rice, millet, cornmeal, amaranth, buckwheat, couscous, teff, quinoa, whole-wheat pasta, flaxseeds, chia seeds, pumpkin seeds, peanuts, walnuts, almonds, sunflower seeds, cashews, date, kiwi, and cumin. However, the cultivation and utilization of some locally grown grain and seed proteins with potential food and nutrition security are grossly underexploited [10]. The locally underexploited grain and seed are tied to the cultural ancestry of their places of origin, acclimate to precise agroecological areas, and perform well in traditional farming systems with little or no external inputs [11, 12]. The new generation of farmers, especially in sub-Sahara Africa, have relegated the locally grown grain and seeds as crops of the older folks. Thus, the traditional farming system is exposed to genetic erosion of the germplasm of the traditional underutilized crops [13]. The formulation of production expansion strategies of the locally grown grain and seed proteins would be a step in the right direction for sustainable intensification and diversification in the global food base.

2. Grain

Grain is a member of the Poaceae family with approximately 780 genera and 12,000 species [14]. The family Poaceae is the fifth-largest plant family following the Asteraceae, Orchidaceae, Fabaceae, and Rubiaceae [15]. They possess a wide range of tolerance for climatic fluctuations; thus, they survive in almost all kinds of ecological niche [16]. The Poaceae are the most economically important plant family, providing staple foods from domesticated cereal crops [17] and feed for

<table>
<thead>
<tr>
<th>Grain</th>
<th>Protein Content (grams)</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain amaranth</td>
<td>6.10</td>
<td>Amaranthus cruentus</td>
</tr>
<tr>
<td>Barley, hulled</td>
<td>5.62</td>
<td>Hordeum vulgare</td>
</tr>
<tr>
<td>Brown rice</td>
<td>3.38</td>
<td>Oryza sativa</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>5.96</td>
<td>Fagopyrum esculentum</td>
</tr>
<tr>
<td>Khorasan wheat</td>
<td>6.57</td>
<td>Triticum turgidum turanicum</td>
</tr>
<tr>
<td>Millet</td>
<td>6.94</td>
<td>Pennisetum glaucum</td>
</tr>
<tr>
<td>Oats rolled</td>
<td>5.92</td>
<td>Avena sativa</td>
</tr>
<tr>
<td>Quinoa</td>
<td>6.35</td>
<td>Chenopodium quinoa</td>
</tr>
<tr>
<td>Rye</td>
<td>4.65</td>
<td>Secale cereale</td>
</tr>
<tr>
<td>Sorghum</td>
<td>5.09</td>
<td>Sorghum bicolor</td>
</tr>
<tr>
<td>Spelt</td>
<td>6.56</td>
<td>Triticum aestivum spelta</td>
</tr>
<tr>
<td>Wheat</td>
<td>6.93</td>
<td>Triticum aestivum</td>
</tr>
<tr>
<td>Wheat, bulgur</td>
<td>5.53</td>
<td>Triticum durum</td>
</tr>
<tr>
<td>Wild rice</td>
<td>6.63</td>
<td>Zizania latifolia</td>
</tr>
</tbody>
</table>

1 All values are based on 45 g uncooked grain – Standard FDA serving size. Source: Oldways Whole Grain Council and Oldways Nutrition Exchange

Table 1. The protein content of some grains.
meat-producing animals. A grain is the tiny edible fruit of the plant, usually hard on the outside harvested from grassy crops. Grains are either referred to as true cereal grains or pseudo-cereal grains. The true cereal grains are the edible seeds of specific grasses from the family of Poaceae.

Examples of true grain cereals include wheat, oat, maize, barley, rye, sorghum, and millet. The pseudo-cereal grains are not really grains but seeds from different plant species with a nutritional composition similar to the true grains. Amaranth, buckwheat, and quinoa are examples of pseudo-cereal grains. Grain foods are consumed for their higher fibre content as well as for dietary proteins. The three critical parts of grains include; the bran (outermost layer), the germ (embryo), and the endosperm [18]. The bran is made up of fibre and B vitamins; the germ contains oils, vitamins, proteins, minerals, and antioxidants; and carbohydrates and protein are found in the endosperm. Grain foods are categorized either as whole or refined grains. Whole grains have been minimally processed and still contain the bran, germ, and endosperm [19]. Whole-grain foods are higher in B vitamins and fibre. Consumption of a whole-grain diet is associated with a lower risk of several diseases [20]. Refined grains are processed grains containing only the endosperm [21]. Refined grain foods are lower in B vitamins and fibre but higher in folate. However, vitamins and minerals (specifically iron and folic acid) lost during processing are added to the refined grain to make it healthier [22]. The protein content in most of the popular grains is shown in Table 1.

3. Seed

A seed is an embryonic plant covered in a seed coat formed from the ripened ovule of the plant after fertilization. The seed comprises three major parts - the embryo, seed coat, and the endosperm [23]. The embryo is the most crucial part because the various tissues that make up the plant are developed from its cells. The endosperm contains the nutrients while the seed coat protects the embryo. The plant seed is not only an organ of propagation and dispersal but also a significant source of dietary protein [24]. The seed contains the complete profile of amino acids needed for the formation of complete and digestible protein. The amount of protein present in seeds vary from 10% (in cereals) to 40% (in particular legumes and oilseeds) of the dry weight. Although the individual protein in seeds either play structural or metabolic roles, seed proteins generally provide a store of amino acids available during germination and seedling growth [25]. Seeds also contain vitamins A, B, C, and E and the minerals calcium, magnesium, potassium, zinc, iron, selenium and manganese. Seeds are edible, and they form the primary source of the majority of human calories when consumed as legumes, cereals and nuts [26]. Plant seeds are a versatile food, used to flavour a stew, as a garnish, in salads and soups. Seeds are a low gastro-intestine (GI) food and help to keep blood sugar level stable. Seeds provide many beverages and spices, cooking oils and some important food additives.

4. Nutritional properties and health benefits of some selected grain and seed

The nutritional property of food is the measure of a well-balanced ratio of the essential nutrients, carbohydrates, fat, proteins, minerals, and vitamins with the nutrient requirements of the consumer. A healthy diet supports average growth, development and ageing. It also helps to maintain a healthy body weight and
Grain and Seed Proteins Functionality

reduces the risk of chronic diseases. The nutritional properties and health benefits of some selected grains are discussed below:

4.1 Barley

Barley is a versatile grain consumed as whole grain (hulled) or pearl barley (refined). Whole grain barley contains a range of vitamins, minerals and other beneficial plant compounds. Barley is packed with fibre and lignans, a group of antioxidants linked to a lower risk of chronic Western diseases [27]. Barley is naturally cholesterol-free and low in fat [28]. It helps to reduce the risk of heart disease, prevent the development of type 2 diabetes, and aid regularity. Barley is a primary source of many nutrients, including molybdenum, manganese, dietary fibre, vitamin B1, chromium, phosphorus, copper, selenium, riboflavin, folate, iron, magnesium and niacin. Barley contains a soluble fibre known as beta-glucan, which forms a gel-like structure in the guts. Beta-glucan slows the digestion and absorption of nutrients, thereby curbing hunger and promoting fullness in man [29]. The high fibre content of barley helps to boost intestinal health [30]. The insoluble fibre in barley helps to prevent the formation of gallstones, aiding the proper functioning of the gallbladder [31]. Whole barley has a nutty flavour which makes it a great addition to soups and stews.

4.2 Sorghum

Sorghum is an old cereal grain of the family Poaceae considered a traditional crop of Africa and Asia [32]. It is small, round, and usually white or yellow grain favoured by farmers due to its tolerance to drought, heat, and other edaphic conditions [33]. Whole grains of sorghum contain approximately 89–90% dry matter (DM), 8.9–15% crude protein (CP), 2.8% ether extract, 1.5–1.7% ash, 2.1–2.3% crude fiber [34]. Protein, oil, niacin, and pyridoxine content of sorghum are highest in the germ fraction and lowest in the bran, while the endosperm contains the highest level of starch [35]. Sorghum is packed with a huge amount of carbohydrate, protein, fat, calcium, vitamin B1, and a small amount of nicotinic acid. It is also an excellent source of riboflavin, thiamin and minerals such as iron, potassium, manganese and magnesium. The B vitamins in sorghum play essential role in metabolism, neural development, skin, and hair health [36]. Sorghum is high in antioxidants such as flavonoids, tannins, and phenolic acids, which help to lower oxidative stress and inflammation of the body [33]. Sorghum is naturally gluten-free and a good option for people with underlining ailments such as celiac disease [37]. Sorghum syrup is widely used as a sweetener in the food industry due to its low total sugar content [38]. Sorghum is versatile, and it is available in milled flour, syrup, and whole or flaked form.

4.3 Quinoa

Quinoa is a tiny, light bead textured grain and contains all nine essential amino acids. Quinoa is gluten-free, high in protein, fibre, magnesium, B vitamins, potassium, iron, calcium, and beneficial antioxidants [39]. As an edible seed, quinoa is increasingly becoming important due to its high nutrient value and its potential to contribute to food security [40]. It is a good source of magnesium, which protects against osteoporosis. Quinoa contains many potent plant antioxidants, including flavonoids (quercetin and kaempferol) reported with anti-inflammatory, anti-cancer, anti-viral, and anti-depressant effects [41]. Quinoa is much higher in fibre
than most grains, but most of the fibre is insoluble. Substituting quinoa for other gluten-free ingredients in food recipe increases the nutrients and antioxidant value of a man’s diet [42]. Quinoa is high in fibre, protein and has a low glycemic index. These properties have been linked to weight loss and healthy living [43]. Quinoa grain is roasted and processed to make different types of bread. It is prepared with strong-flavoured vegetables such as kale, spinach and red peppers. It can also be added to soups, used as a cereal, made into pasta or even fermented to beer [40].

4.4 Brown rice

Brown rice is considered as a whole grain food recommended as a healthy diet. The brown colour is from the bran, and germ layers left intact after harvesting the rice. Brown rice is highly nutritious, providing the body with an array of vitamins and minerals, including carbohydrate, fibre, fat, protein, potassium, B vitamins, magnesium, zinc, iron, selenium, and manganese [44]. Brown rice is exceptionally high in manganese, a vital mineral for body processes such as bone development, blood sugar regulation, and wound healing, amongst others [45]. The consumption of fibre-rich brown rice helps reduce belly fat and enhances weight loss [46]. The brown coat is responsible for its nuttier taste and chewy texture. It is also a good source of bioactive peptides [47]. Brown rice is naturally gluten-free and can be made into wholesome gluten-free products such as crackers and pasta.

4.5 Wheat berries

Wheat berries these are oval-shaped, chewy textured whole wheat kernel with a robust and sweet taste. Wheat berries are high in fibre, protein, iron and packed with an array of micronutrients, including manganese and selenium. Wheat berries are a good source of dietary fibres that protect against intestinal ulcers and improve irritable bowel syndrome symptoms [48]. Incorporating wheat berries into diet protects against diabetes [49]. Diets rich in whole grain like wheat berries reduce the risk of obesity [50]. Wheatberry is rich in iron and promotes healthy red blood cell production. Wheat berries enhance subtly flavoured foods, such as chicken and shellfish. Wheat is a good source of bioactive peptides [51]. When combined with other whole-grain to form a well-balanced and healthy diet, wheat berry can significantly influence many aspects of overall health. Wheatberry can be cooked and used to ad a crunch to dishes, ground into wheat flour, or grow into wheatgrass.

4.6 Buckwheat

Buckwheat is a pseudo-cereal ground into flour. There are two types of buckwheat: common buckwheat (Fagopyrum esculentum) and Tartary buckwheat (Fagopyrum tartaricum). The dietary components of buckwheat include carbohydrate, protein, fibre, various minerals and antioxidants. The fibre content of buckwheat is minimal, and it is suitable for colon health [52]. The protein in buckwheat is rich in the amino acids lysine and arginine. Buckwheat protein tested in animals has proven effective at lowering blood cholesterol, reducing the risk of colon cancer, and suppressing gallstone formation [53]. Buckwheat has higher minerals compared to other pseudo-cereals and cereals. The most abundant minerals in buckwheat include magnesium, copper, manganese, iron and phosphorus [54]. Buckwheat is rich in various antioxidant plant compounds, including rutin, quercetin, vitexin, and D-Chiro-inositol [55]. The nutty, bitter flavour of whole-grain wheat flour is delicious in chocolate chip cookies and gluten-free pastries.
4.7 Oats

Oats a vital cereal crop with high dietary fibre content and nutritive value [56]. Oat consumption is beneficial to man because it possesses quality protein with the right amino-acid balance, minerals, vitamins, dietary fibres, including functional protein, lipid, starch components β-glucan and phytochemicals [57]. Oats are high in antioxidants, including avenanthramides. These compounds help reduce blood pressure and have anti-inflammatory and anti-itching effects [58]. The health benefits associated with the nutritional fibres have increased interest in its use as a food ingredient in various food products by the food industry [59, 60]. Food products derived from oat include oatmeal, porridge, granola bars, bread, biscuits, cookies, oat-based probiotic drink, oat-based breakfast cereals, flakes and infant food.

4.8 Grain amaranth

Grain amaranth is not a true grain but contains all nine essential amino acids missing from most grains. Amaranth is a good source of bioactive peptides [61]. Niacin, riboflavin and thiamine are essential micronutrients present in grain amaranth. These micronutrients enhance proper blood circulation, healthy functioning of the nervous system, maintenance of the gastrointestinal tract and proper metabolism of proteins and carbohydrate [62]. Grain amaranth is rich in protein, carbohydrate, fat, ash and energy needed for healthy living. It also contains essential minerals, namely zinc, iron, magnesium and manganese. These minerals stabilise the immune, alleviate anaemic conditions, and enhances the infant’s growth [62]. Grain amaranth is popular in gluten-free baking as muffins and puffed granola.

5. Nutritive properties and health benefits of some selected underutilised grains and seeds

5.1 African yam bean (Sphenostylis stenocarpa)

African yam bean (Sphenostylis stenocarpa) is one of the under-utilised hardy, cheap, protein-rich legume indigenous to Africa with great medicinal values [63]. The plant, when harvested, can be consumed as seed and tuber [64]. African yam bean seed contains protein with a value range between 19 and 30%. The seed is also rich in dietary fibre, carbohydrate, and essential minerals such as calcium, iron, zinc, and magnesium, with values as high as those of other vital legumes [65]. The carbohydrate composition of African yam bean is majorly starch with slowly digestible properties beneficial for diabetic patients [66]. African yam bean is also a good source of non-starchy polysaccharides, reducing the risks posed by cardiovascular disorder, coronary heart diseases, cancers, type 2 diabetes, and other lifestyle disorders [67]. African yam bean seed has a low-fat content when compared with crude legumes such as soybean and groundnut. The low-fat content of African yam bean seed makes it ideal as a promising food crop for weight management [66]. The prevalent amino acids in African yam bean include aspartic acid, glutamic acid, leucine and lysine. The fortification of protein-deficient cereal-based diets with African yam bean addresses kwashiorkor and marasmus among infants [68]. It is a hearty food in west Africa, where millions are suffering from protein-energy malnutrition. African yam bean is used to fortify and enrich foods low in protein to address the problem of protein malnutrition [64]. African yam bean is used as composite flour with rice and brown cowpea seeds, breakfast meals, maize-African yam bean meal composite, African yam bean enriched fufu, traditional snack food, and as imitation yoghurt [64, 69].
5.2 Bambara groundnut (*Vigna subterranea*)

Bambara groundnut (*Vigna subterranea*) is the third most important in most parts of Africa legume after peanuts and cowpeas. Bambara seeds (ripe or immature) are nutrient-rich and unusually high in amino acid, with more methionine than other grain legumes. They contain approximately 64.4% carbohydrate, 23.6% protein, 6.5% oil, 5.5% fiber, and are rich in micronutrient [70, 71]. Bambara groundnut is a good source of magnesium, calcium, iron, zinc, and potassium [32]. Bambara seeds and flour are used to produce myriads of traditional foods in Africa [72]. It can be used as a condiment in cooking, making flour or eaten as a snack. Bambara groundnut can be pounded into flour and used to make a stiff porridge. Raw and cooked seeds of Bambara groundnut have an abundance of epicatechin and catechin flavonoids [73]. Catechin and epicatechin polymerize to form proanthocyanidins, also known as condensed tannins. Proanthocyanidins are documented with nutraceutical properties such as cardioprotective, antitumor, antioxidant, and neuroprotective properties [74]. The nutritional profile of Bambara groundnut sustains the growth of probiotics (live microorganisms which confer certain health benefits on their hosts). These benefits are therapeutic, suppressing the growth and activity in conditions like infectious diarrhoea, irritable bowel syndrome, and inflammatory bowel disease [75].

5.3 Pigeon pea (*Cajanus cajan*)

Pigeon pea (*Cajanus cajan*) is mainly cultivated as edible seed grain and an alternative source of protein among farmers in lean times [76]. Pigeon pea is a good source of protein, dietary fibre, and various vitamins: thiamin, magnesium, phosphorus, potassium, copper, and manganese. Pigeon pea is also low in saturated fat, cholesterol, and sodium. Pigeon pea is a good source of protein, dietary fibre, and various vitamins: thiamin, magnesium, phosphorus, potassium, copper, and manganese. The potassium found in pigeon pea is best described as a vasodilator; it helps reduce the constriction of blood vessels, thereby lowering the risk of hypertension and other cardiovascular diseases [77]. Pigeon pea has a densely packed protein content responsible for routine healing and regeneration of cells in the human body. Pigeon pea has high folate levels, which helps prevent anaemia and neural tube defects in unborn babies [78]. Pastes from mashed pigeon pea is used in traditional medicine for the treatment of haemorrhoids [79]. Pigeon pea is low in saturated fat and cholesterol and moderate in terms of dietary fibre content.

5.4 Winged bean (*Psophocarpus tetragonolobus*)

Winged bean (*Psophocarpus tetragonolobus*) is an underutilised, nutrient-rich legume with potential as a significant multi-use food crop. Winged bean seed contains high dietary protein due to its amino-acid content, substantial protein bioavailability, and low antinutritional factors [80]. The carbohydrate content in unprocessed winged bean seed is higher than in processed winged bean seed [81]. The moderate carbohydrate content in winged bean flour makes it a good source of energy in breakfast formulations. The crude fibre content of winged bean seed is reported higher than that of most legumes. The seeds can be functional food with health benefits associated with soluble and insoluble fibre [82]. Winged bean seed can be dried and ground into flour and brewed to make a coffee-like drink. Winged bean is rich in protein and tocopherol, facilitating the utilisation of vitamin A in the body [83].
5.5 Mung bean

Mung bean is a substantive source of dietary protein containing a greater quantity of essential amino acids. Mung bean’s palatable taste and high nutritional quality have endeared it as an iron-rich dietary source for infants and children. The dry weight of mung bean is composed of 20–25% protein, 55–65% carbohydrate, and vitamins and minerals. Mung bean contains much health benefiting bioactive compounds. The compounds are responsible for the antidiabetic, antihypertensive effect, anti-tumour, anti-inflammatory, and anti-mutagenic properties of the mung bean [84]. Mung bean is consumed as a fresh salad, vegetable, or ordinary food, and it is used to alleviate heat stroke [85]. The paste made out of mung bean can be used to relieve itching, treat acne, eczema and dermatitis [86].

6. Nutritive properties and health benefits of some selected seed

6.1 Flaxseeds

Flaxseeds is one of the best sources of plant-proteins and it contains omega-three fatty acids. They are also rich in vitamins and minerals such as magnesium, phosphorus and copper. Flaxseeds are rich in lignans (plant compounds with antioxidant and oestrogen properties), which lowers cancer risk and relieves menopausal symptoms. Flaxseed contains both soluble and insoluble fibres, which are worked upon by the bacteria in the large bowel, bulk up stools to allow regular bowel movements. The soluble fibres increase the intestine’s consistency and slow down the rate of digestion. The insoluble fibres aid with the prevention of constipation by allowing more water to bind up the stools, increase their bulk to allow for softer stools. Flaxseed protein helps to improve the body’s immunity, lowers cholesterol level, prevents tumour and has antifungal properties. Flaxseeds have health-impacting benefits such as reducing cardiovascular disease, decreased risk of cancer, anti-inflammatory activities, and laxative effects [87].

6.2 Chia seeds

Chia seeds are tiny dark seeds packed with proteins and nutrients including iron, calcium, thiamin, manganese, magnesium, zinc, phosphorus, B-vitamins, folate and riboflavin. The carbohydrate content of chia seeds is majorly in fibre, and this insoluble fibre makes humans less prone to diabetes [49]. Chia seeds are a high-quality plant-based protein since the seeds contain all the nine essential amino acids. Chia seeds contain beneficial plant compounds such as chlorogenic acids, caffeic acid, quercetin, and kaempferol, which help reduce chronic illnesses [88]. Chia seeds are versatile. They can be soaked and added to porridge, used in baked goods, and sprinkled on top of salads or yoghurt.

6.3 Pumpkin seeds

Pumpkins are a widely cultivated vegetable worldwide, used for human consumption and traditional medicine [89]. There are different species of pumpkins, all belonging to the genus *Cucurbita*, and are an essential source of carotenoid [90]. Pumpkin contains crispy flavourful seeds rich in amino acids. Pumpkin seed is high in protein content, iron, phosphorus and low in carbohydrates. Pumpkin seeds are a treasured trove of vitamins, minerals and antioxidants. In traditional medicine and modern therapy, pumpkin seeds are used to treat minor disorders of the
prostate gland and urinary bladder [91, 92]. Powdered pumpkin seeds mixed with cereals are roasted, baked as bread and eaten as snacks [89]. Pumpkin seeds are rich in unsaturated fatty acids, namely palmitic acid, stearic acid, oleic acid and linoleic acid [93].

6.4 Sesame seeds

Sesame Seeds are tiny, oil-rich seeds with many potential health benefits and long-standing history in traditional folk medicine [94]. The tiny seeds, hulled or unhulled, are packed with protein, iron, zinc, magnesium, calcium and phytic acid, and low carbohydrates. Sesame seeds contain 15% saturated fat, 41% polyunsaturated fat, and 39% monounsaturated fat [95]. Studies have shown that more polyunsaturated fat and monounsaturated fat relative to saturated fat helps lower cholesterol level and reduce heart disease risk [96]. Hulled sesame seeds are a good source of protein which is a necessary building block of the body. Sesame seeds are rich in B vitamins– niacin, thiamine, and vitamin B6, essential for proper cellular function and metabolism. Sesame seeds contain sesamin – a compound with anti-inflammatory and antioxidant effects reported to soothe arthritic knee pain [97]. Ground sesame seed (sesame flour) can be used in smoothies, fish batter, baking, and more.

6.5 Sunflower seeds

Sunflower seeds are white tender-texture seeds encased in a black and white striped shell of the sunflower plant. Sunflower seeds have a distinct nutty flavour and high nutritional value – the seeds can be eaten raw, roasted or incorporated with other dishes. Sunflower seeds have a good amount of fibre, rich in protein and calories, and contain majorly polyunsaturated and monosaturated fats. The seeds are loaded with vitamins and minerals like sodium, potassium, phosphorus, calcium, iron, magnesium, manganese and zinc. The vitamins and minerals in sunflower seeds enhance body immunity, reduce cholesterol levels, and protect against cardiovascular diseases [98]. Sunflower seeds also contain plant compounds such as flavonoids and phenolic acids that are potent antioxidants [99]. As a natural source of zinc, sunflower seeds are immune boosters.

6.6 Almonds (Prunus dulcis)

Almonds (Prunus dulcis) are not true nuts. The edible part commonly referred to as a nut is a seed. Almonds are rich in monounsaturated healthy fats, fibre, protein and other essential nutrients. The brown layer of the almond seed contains powerful antioxidants that protect the body against oxidative-stress related diseases [100]. Almonds are high in vitamin E, which lowers the rates of heart disease, cancer and Alzheimer disease [101]. It has been documented that consumption of almonds reduces hunger and lowers overall calorie intake [102]. Almonds are used to produce milk, oil, butter, flour or paste.

7. Pharmacological properties associated with bioactive peptides in grains and seeds

Proteins and peptides derived from grains and seeds play essential roles in the metabolic functions of man and, consequently, in his general well-being. They exhibit drug-like activities and can be classified based on their mode of action as
antimicrobial, antihypertensive, immunomodulatory, and antioxidative [103]. Bioactive peptides are fast evolving as the new generation of biologically active regulators used to treat various medical conditions and increase the quality of life [104]. Pumpkin seeds contain a wide range of bioactive compounds reported with antidiabetic, antibacterial, hypocholesterolemic, antioxidant, anticancer, anti-mutagenic, immunomodulatory, antihelmintic, and anti-bladder stone potentials [105, 106]. Soybean generates bioactive peptides reported to treat induced arthritis and inflammatory bowel diseases in experimental animals [107–109]. Bioactive peptides from wheat gluten hydrolysate have been used to treat chemically-induced hepatitis in animal [110]. Rapeseed protein hydrolysate is also reported with anti-carcinogenic properties [111]. Wheat and barley exhibit the most incredible diversity and abundance of peptides with potential biological activity among the cereal proteins [112]. Also, wheat and rice have proteins with peptidic sequences showing anticancer activity. Oat derived peptides (lunasin) have been reported to have anti-inflammatory and anti-cancerous properties [113]. African yam bean is reported as a source of phytochemicals and bioactive compounds, including flavonoids and phenolic acids [114]. These bioactive compounds in African yam bean have antioxidant effects and are effective prophylactic and therapeutic compounds against several diseases. The hydrolysates of Bambara groundnut protein isolates have been reported to exhibit potent antioxidant activities and food preservative and functional food properties [115]. The bioactive peptides of Bambara groundnut isolates were also found to inhibit renin and angiotensin-converting enzyme, two components known to be associated with hypertension [116]. Peptide mixture from flaxseed with high levels of branched-chain amino acids and low levels of aromatic amino acids have been reported with antioxidant properties by scavenging 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) and antihypertensive properties by inhibiting the ACE activity [117].

8. Conclusion

Grain and seed are nutritious, healthy foods that raise the nutritional effectiveness of the malnourished majority in the developing parts of the world. They are crucially important as a poor man’s meat to the vast majority who cannot afford livestock products. Grain and seed contain proteins and bioactive peptides, which are referred to as active biological regulators. These proteins and bioactive peptides possess specific functional components incorporated into food products for wholesome nutrition. Besides providing healthy nutrition, grain and seed-derived proteins and peptides have bioactive ingredients endowed with protection against various degenerative diseases, promoting health and therapeutic use. Peptide-rich protein hydrolysates and bioactive peptides provide a better alternative to synthetic pharmaceuticals to prevent and treat chronic illnesses affecting many [118]. The increasing awareness of biosafety products should encourage the commercial exploration of pharmaceutic potential in naturally-derived peptides targeted at improving human health. Furthermore, peptide-rich protein hydrolysates and bioactive peptides in grain and seeds can be developed into micro and nanocapsules for inclusion in foods.
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Grain and Seed Proteins Functionality


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