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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

the resource-poor farming communities. 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, oatmeal, 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

Grain ¹	Protein Content (grams)	Scientific Name
Grain amaranth	6.10	<i>Amaranthus cruentus</i>
Barley, hulled	5.62	<i>Hordeum vulgare</i>
Brown rice	3.38	<i>Oryza sativa</i>
Buckwheat	5.96	<i>Fagopyrum esculentum</i>
Khorasan wheat	6.54	<i>Triticum turgidum turanicum</i>
Millet	6.96	<i>Pennisetum glaucum</i>
Oats rolled	5.92	<i>Avena sativa</i>
Quinoa	6.35	<i>Chenopodium quinoa</i>
Rye	4.65	<i>Secale cereale</i>
Sorghum	5.09	<i>Sorghum bicolor</i>
Spelt	6.56	<i>Triticum aestivum spelta</i>
Wheat	6.93	<i>Triticum aestivum</i>
Wheat, bulgur	5.53	<i>Triticum durum</i>
Wild rice	6.63	<i>Zizania latifolia</i>

¹All 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 foliate. 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

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 add 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 subterranean*)

Bambara groundnut (*Vigna subterranean*) 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 is 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 polysaturated 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, antihelminthic, 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 pharmaceutical 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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References

- [1] UN. 2011. World Economic and Social Survey 2011: The great green technological transformation. New York: Department of Economic and Social Affairs, United Nations
- [2] IFAD. 2011a. Rural groups and the commercialisation of smallholder farming: Targeting and development strategies (draft). (Issues and perspectives from a review of IOE evaluation reports and recent IFAD country strategies and project designs.) Rome: International Fund for Agricultural Development
- [3] FAO. 2011a. The State of the World's Land and Water Resources for Food and Agriculture (SOLAW) – Managing systems at risk. Rome: Food and Agriculture Organization of the United Nations; London: Earthscan
- [4] Khush G, Lee S, Cho J-I, Jeon JS. Biofortification of crops for reducing malnutrition. *Plant Biotechnology Reports*. 2012; 6: 195-202
- [5] Sonawane S.K, Arya AS. Plant Seed Proteins: Chemistry, Technology and Applications. *Curr Res Nutr Food Sci* 2018; 6(2). doi:<http://dx.doi.org/10.12944/CRNFSJ.6.2.20>
- [6] Moldes AB, Vecino X, Cruz JM. Nutraceuticals and food additives. In Pandey, A., Du, G., Sanroman, M. A., Soccol, C. R., Dussap, C-G. (eds.), *Current Developments in Biotechnology and Bioengineering: Food and Beverages Industry*, Elsevier, Amsterdam, Netherlands. 2017; pp. 143-164
- [7] Hackler LR. Cereal proteins in human nutrition. In: Lásztity, R., Hidvégi, M, (eds) *Amino acid composition and biological value of cereal proteins*. Springer, Dordrecht. 1985; https://doi/10.1007/978-94-009-5307-9_6
- [8] Tharanathan RN, Mahadevamma S. Grain legumes a boon to human nutrition. *Trends Food Sci. Technol*. 2003; 14:507-518
- [9] Bhat ZF, Kumar S, Bhat HF. Bioactive peptides from egg: a review. *Nutrition and Food Science*. 2015a; 45: 190-212
- [10] Saka JO, Ajibade SR, Adeniyi ON, Olowoyo RB, Ogunbodede BA. Survey of underutilized grain legume production systems in the Southwest Agricultural Zone of Nigeria. *Journal of Agricultural and Food Information*. 2004; 6:2-3, 93-108
- [11] Cullis C, Kunert KJ. Unlocking the potential of orphan legumes. *Journal of Experimental Botany*. 2017; 68(8): 1895-1903
- [12] Mabhaudhi T, Chimonyo VGP, Chibarabada TP, Modi AT. Developing a roadmap for improving neglected and underutilized crops: A case study of South Africa. *Frontiers in Plant Science*. 2017; 8:2143
- [13] Popoola JO, Obembe OO, Adegbite AE. Cytological studies on some accessions of African yam bean (AYB) (*Sphenostylis stenocarpa* Hochst. Ex. A. Rich. Harms). *International Journal of Plant Science*. 2011; 2(8): 249-253
- [14] Christenhusz MJM, Byng JW. The number of known plant species in the world and its annual increase. *Phytotaxa*. 261 (3): 201-217
- [15] Angiosperm Phylogeny. Archived from the original on March 2016. Retrieved 20 March 2016
- [16] Sarandón R. Biología poblacional del gramon (*Cynodon* spp., Graminae). 1988; 189. Archived from the original on 11 September 2014. Retrieved 22 April 2014

- [17] Rice is life. Food and Agricultural Organization of the United Nations, 2004
- [18]] The wheat grain. *Plant Foods Human Nutrition*; 2000; 55:15-20
- [19] van der Kamp (2013). Whole grain definition: New perspectives for inclusion of grains and processing but not for analysis. *CFW Plexus*. Doi: 10.1094/CPLEX-2013-1001-08B
- [20] Aune D, Keum N, Giovannucci E, Fadnes LT, Boffetta P, Greenwood DC, Tonstad S, Vatten LJ, Riboli E, Norat T. Whole grain consumption and risk of cardiovascular disease, cancer, and all cause and cause specific mortality: Systemic review and dose-response meta-analysis of prospective studies. *BMJ*: i2716. Doi:10.1136/bmj.i2716
- [21] Marcus, J.B. Carbohydrate Basics: Sugars, Starches and Fibers in Foods and Health: Healthy Carbohydrate Choices, Roles and Applications in Nutrition, Food Science and Culinary Arts. *Culinary Nutrition*. 2013; pg 149-187
- [22] American Heart Association. Whole grains, refined grains and dietary fiber. Updated, September 20 2016
- [23] Kivumbi. Difference between seeds and grains. "DifferenceBetween.net. November 8, 2018" < <http://www.differencebetween.net/science/difference-between-seeds-and-grains>
- [24] Shewry PR, Napier JA, Tatham AS. Seed Storage Proteins: Structures and Biosynthesis. *The Plant Cell*. 1995; 7:945-956
- [25] Rebecca MB, Griffiths GA, Sammy S. Physicochemical and functional properties of medium-sized broken rice kernels and their potential in instant rice production, *Cereal Chemistry*. 2020; 10.1002/cche.10284, 97, 3, (681-692)
- [26] Sabelli PA, Larkins BA. The development of endosperm in grasses. *Plant Physiology*, 2009; 149(1):14-26
- [27] Adlercreutz H. Lignans and human health. *Crit Rev Clin Lab Sci*, 2007; 44(5-6):483-525
- [28] Talati R, Baker WL, Pablonia MS, White CM, Coleman CI. The effects of barley-derived soluble fiber on serum lipids. *Ann Fam Med*, 2009; 7(2): 157-163
- [29] Wanders AJ, Borne van den JJGC, Graaf de C, Hulshof T, Jonathan MC, Kristensen M, Mars M, Schools HA, Feskens EJM. Effects of dietary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials. *Obs Rev*. 2011; 12(9):724-739
- [30] Bourdon I, Yokoyama W, Davis P, Hudson C, Backus R, Richter D, Knuckles B, Schneeman BO. Postprandial lipid, glucose, insulin, and cholecystokinin responses in men fed barley pasta enriched with beta-glucan. *Am J Clin Nutr* 1999; 69(1):55-63
- [31] Sulaberidze G, Okujava M, Liluashvili K, Tughushi M, Bezarashvili S. Dietary fiber's benefit for gallstone disease prevention during rapid weight loss in obese patients. *Georgian Med News*. 2014;(231): 95-99
- [32] Maunder AB. Sorghum worldwide. 2002; p. 11-17. In: J.F. Leslie (ed.). *Sorghum and millet diseases*. Iowa State Press, Ames, IA, USA
- [33] Xiong Y, Warner RD, Fang Z. Sorghum grain: From genotype, nutrition, and phenolic profile to its health benefits and food applications. *Comprehensive Reviews in Food Science and Food Safety* 2019; 18(6):2025-2046
- [34] Ensminger ME, Olentine CG. *Feeds and Nutrition – Abridged*. 1st Edition.

The Ensminger Publishing Company,
Covis, Carlifornia; 1978

[35] Etuk E.B, Ifeduba AV, Okata UE, Chiaka I, Okoli IC, Okeudo NJ, Esonu BO, Udedibie ABI, Moreki JC. Nutrient composition and feeding value of sorghum for livestock and poultry: A Review. *J Anim Sci Adv.* 2012; 2(6):510-524

[36] Almohanna HM, Ahmed AA, Tsatalis JP, Tosti A. The role of vitamins and minerals in hair loss: A Review. *Dematol Ther (Heidelb).* 2019; 9(1):51-70

[37] Parzanese I, Qehajaj D, Patrinicola F, Aralica M, Chiriva-Internati M, Stifter S, Elli L, Grizzi F. Celiac disease: From pathophysiology to treatment. *World J Gastrointest Pathophysiol.* 2017; 8(2):27-38

[38] Asikin Y, Wada K, Imai Y, Kawamoto Y, Mizu M, Mutsuura M, Takahashi M. Composition, taste characteristics, volatile profiles, and antioxidant activities of sweet sorghum (*Sorghum bicolor* L.) and sugarcane (*Saccharum officinarum* L) syrups. *Food Measure* 2018; 12, 884-891

[39] James LEA. Quinoa (*Chenopodium quinoa* Wild): Composition, chemistry, nutritional, and functional properties. *Adv Food Nutr Res.* 2009; 58:1-31

[40] FAO. 2013. The International year of quinoa. FAOSTAT data on quinoa

[41] Peñarrieta JM, Alvarado JA, Akesson B, Bergenstahl. Total antioxidant capacity and content of flavonoids and other phenolic compounds in canihua (*Chenopodium pallidicaule*): an Andean pseudocereal. *Mol Nutr Food Res.* 2008; 52(6):708-717

[42] Lee AR, Ng DL, Dave E, Ciaccio EJ, Green PHR. The effect of substituting alternative grains in the diet on the

nutritional profile of the gluten-free diet. *J Hum Nutr Diet.* 2009; 22(4):359-363

[43] Roberts SB. High-glycemic index foods, hunger, and obesity: Is there a connection? *Nutrition Reviews,* 2009; 58(6):163-169

[44] Nutrition information for rice, brown, long grain. United State Department of Agriculture (USDA SR-21) <https://nutritiondata.self.com/facts/cereal-grains-andpasta/5707/2>

[45] Bowman AB, Kwakye GF, Hernández EH, Aschner M. Role of manganese in neurodegenerative diseases, *J Trace Elem Med Biol.* 2011; 25(4):191-203

[46] Kazemzadeh M, Safavi SM, Nematollahi S, Nourieh Z. Effect of brown rice consumption on inflammatory maker and cardiovascular risk factors among overweight and obese non=menopausal female adult. *Int J Prev Med.,* 2014; 5(4):478-488

[47] Selamassakul O, Laohakunjit N, Kerdchoechuen O, Ratanakhanokchai K. A novel multi-biofunctional protein from brown rice hydrolysed by endo/ endo-exoproteases. *Food Funct.* 2016; 7(6):2635-2644

[48] El-Salhy M, Ystad SO, Mazzawi T, Gundersen D. Dietary fiber in irritable bowel syndrome (Review). *Int J Mol Med* 2017; 40(3):607-613.

[49] de Munter JSL, Hu FB, Spiegelman D, Franz M, van Dam RB. Whole grain, bran and germ intake and risk of Type 2 Diabetes: A prospective cohort study and systemic review. *PLoS Med* 4(8): e261

[50] Harland JI, Garton LE. Whole-grain intake as a marker of healthy body weight and adiposity. *Public Health Nutr* 2008; 11(6):554-563

- [51] Kumagai H. Wheat proteins and peptides. In: Mine, Y. Li-Chan, E., Jiang, B. (eds). *Bioactive proteins and peptides as functional foods and nutraceuticals*. Wiley Blackwell, Oxford; 2010
- [52] Leonel AJ, Alvarez-Leitel JI. Butyrate: implications for intestinal function. *Curr Opin Clin Nutr Metab Care*. 2012; 15(5):474-479
- [53] Tomotake H, Shimaoka I, Kayashita J, Yokoyama F, Nakajoh M, Kato N. A buckwheat protein product suppresses gallstone formation and plasma cholesterol more strongly than soy protein isolate in hamsters. *J. Nutr*. 2000; 130(7):1670-1674
- [54] Rosanoff A, Weaver CM, Rude RK. Suboptimal magnesium status in the United States: are the health consequences underestimated? *Nutr Rev* 2012; 70(3):153-164
- [55] Zieliński H, Kozłowska H. Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions. *J. Agric Food Chem*. 2000; 48(6): 2008-2016
- [56] Rasane P, Jha A, Sabikhi, L, Kumar A, Unnikrishnan VS. Nutritional advantages of oats and opportunities for its processing as value added foods. A review. *J Food Sci Technol*. 2015; 52(2): 662-675
- [57] Head DS, Cenkowski S, Arntfield S, Henderson K. Superheated steam processing of oat groats. *LWT – Food Sci Technol*. 2010; 43, 690-694
- [58] Meydani M. Potential health benefits of avenanthramides of oats. *Nutr Rev*. 2009; 67(12):731-735
- [59] Gupta S, Cox S, Abu-Ghannam N. Process optimisation for the development of a functional beverage based on lactic acid fermentation of oats. *Biochem Eng J*. 2010; 52, 199-204
- [60] Ballabio C, Uberti F, Manferdelli S, Vacca E, Boggini G, Redaelli R, Catassi C, Lionetti E, Penas E, Restani P. Molecular characterisation of 36 oat varieties and in vitro assessment of their stability for celiac's diet. *J Cereal Sci*. 2011; 54, 110-115
- [61] Silva-Sanchez C, de la Rosa APB, Leon-Galvan MF, de Lumen BO, de Leon-Rodriguez A, de Mejia EG. Bioactive peptides in amaranth (*Amaranthus hypochondriacus*) seed. *Journal of Agricultural and Food Chemistry*. 2008; 56:1233-1240
- [62] Abolaji GT, Olooto FM, Ogundele DT, Williams FE. Nutritional characterisation of grain amaranth grown in Nigeria for food security and healthy living. *Agrosearch*. 2017; 17(2):1-10
- [63] Machuka JS, Okeola OG, Chrispeel MJ, JackaI LE. The African yam bean seed lectin affects the development of the cowpea weevil but does not affect the development of larvae of the legume pod borer. *Phytochemistry*. 2000; 53(6): 667-674
- [64] Idowu A. Development, nutrient composition and sensory properties of biscuits produced from composite flour of wheat and African yam bean. *Bri. J. Appl. Sci. Technol*. 2014; 4, 1925-1932
- [65] Anya MI, Ozung PO. Proximate, mineral and anti-nutritional composition of raw and processed African yam bean (*Sphenostylis stenocarpa*) seeds in Cross River State, Nigeria. *Global J. Agric. Sci*. 2019; 18,19
- [66] Baiyeri S, Uguru M, Ogbonna P, Samuel-Baiyeri CC, Okechukwu R, Kumaga F, Amoatey C. Evaluation of nutritional composition of the seeds of some selected African yam bean (*Sphenostylis stenocarpa*). *Agro. Sci. J. Trop. Agric. Food Environ. Est*. 2018; 17, 37-44

- [67] Kumar V, Sinha AK, Makkar HPS, de Boeck K. Dietary rules of non-starch polysaccharides in human nutrition: A Review. *Crit. Rev. Food Sci. Nutr.* 2012; 52, 899-935
- [68] Ade-Omowaye BIO, Tacker GA, Smetamka I. Nutritional potential of nine underexploited legumes in Southwest Nigeria. *Int. Food Res. J.* 2015; 22, 798-806
- [69] Babarinde G, Adeyanju J, Omogunsoye A. Protein enriched breakfast meal from sweet potato and African yam bean mixes. *Bangladesh J. Sci. Ind. Res.* 2019; 54, 125-130
- [70] Halimi AR, Mayes S, Barkla B, King G. The potential of the underutilised pulse bambara groundnut (*Vigna subterranea* (L.) Verdc.) for nutritional food security. *J Food Compos Anal.* 2019; 77:47-59
- [71] Murevanhema YY, Jideani VA. Potential of Bambara groundnut (*Vigna subterranea* (L.) Verdc) milk as probiotic beverage – A Review. *Critical reviews in Food Science and Nutrition.* 2013; 53 (9): 954-967
- [72] Bultosa G, Molapisi M, Tselaesele N, Kobue-Lekalaki R, Haki GD, Makhabu S, et al. Plant-based traditional foods and beverages of Ramotswa village, Botswana. *J. Ehtn Foods.* 2020; 7:1-15
- [73] Mubaiwa J, Fogliana V, Chidewe C, lineman AR. Influence of salt cooking on solubilisation of phenolic compounds of Bambara groundnut (*Vigna subterranean* (L.) Verdc.) in relation to cooking time reduction. *LWT Food Sci Technol.* 2019; 107:49-55
- [74] Rauf A, Imran M, Abu-Izneid T, Iahtisham-UI-Haq, Patel S, Pan X, et al. Proanthocyanidins: A comprehensive review. *Biomed Pharmacother.* 2019; 116:108999
- [75] Amarteifio JO, Tibe O, Njogu RM. The mineral composition of bambara groundnut (*Vigna subterranea* (L.) Verdc) grown in Southern Africa. *Afr J Biotechnol.* 2006; 5:2408-2411
- [76] Munoz N, Liu A, Kan L, Li MW, Lam, HM. Potential uses of wild germplasms of grain legumes for crop improvement. *International Journal of Molecular Sciences.* 2017; 18(2):1-28
- [77] Paul KW, Jiang H, Jeffrey AC, Frederick LB, Lawrence AP, Dean F, Michael JK. Effects of oral potassium on blood pressure meta-analysis of randomized controlled clinical trials. *JAMA.* 1997; 277(20):1624-1632.
- [78] Akojie FO, Fung LW. Antisickling activity of hydroxybenzoic acid in *Cajanus cajan*. *Planta Medica.* 1992; 58(4):317-320
- [79] Yi-Syvan L, Wei-Hsuan H, Jan-Jeng H, She-Ching W. Antioxidant and anti-inflammatory effects of pigeon pea (*Cajanus cajan* L.) extracts on hydrogen peroxide- and lipopolysaccharide-treated RAW 2647 macrophages. *Food and Function.* 2012; 3, 1294-1301
- [80] Wan Mohtar WA-QI, Hamid AA, Abd-Aziz S, Syed Muhamad SK, Saari N. Preparation of bioactive peptides with high angiotensin converting enzyme inhibitory activity from winged bean (*Psophocarpus tetragonolobus* (L.) DC.) seed. *Journal of Food Science and Technology,* 2014; 51(12):3658-3668
- [81] Mohanty CS, Pradhan RC, Singh V, et al. Physicochemical analysis of *Psophocarpus tetragonolobus* (L.) DC seeds with fatty acids and total lipids compositions. *Journal of Food Science and Technology,* 2015; 52(6):3660-3670
- [82] Singh PK, Ningombam RD, Salam JS. Proximate composition and nutritional evaluation of underutilized

- legume *Psophocarpus tetragonolobus* (L.) DC. Grown in Manipur, Northeast India. *American Journal of Food Technology*, 2012; 7(8):487-493
- [83] Yang J, Tan H. *Winged Bean Milk. International Conference on New Technology of Agricultural Engineering, Zibo*. 2011; pp. 814-817
- [84] Ganesan K, Xu B. A critical review of phytochemical profile and health promoting effects of mung beans (*Vigna radiata*). *Food Science and Human Wellness*. 2018; 7(1): 11-33
- [85] Tang D, Dong Y, Ren H, Li L, He C. A review of phytochemistry, metabolite changes, and medicinal use of the common food mung bean and its sprouts (*Vigna radiata*). *Chem. Cent. J*. 2014; 8, p.4
- [86] Liu T, Yu XH, Gao EZ, Liu XN, Sun LJ, Li HL, Wang P, Zhao YL, Yu ZG. Hepatoprotective effect of active constituents isolated from mung beans (*Phaseolus radiatus* L.) in an alcohol-induced liver injury mouse model. *J. Food Biochem*. 2014; 38: 453-459
- [87] Goyal A, Sharma V, Upadhyay N, Gill S, Sihag M. Flax and flaxseed oil: an ancient medicine & modern functional food. *J Food Sci Technol*. 2014 Sep;51(9):1633-53
- [88] Calderón-Montaña JM, Burgos-Murón E, Pérez-Guerrero C, López-Lázaro M. A review on the dietary flavonoid kaempferol. *Mini Rev Med Chem*, 2011; 11(4):298-344
- [89] Krimer-Malešević V, Madarev-Popović S, Vaštag Ž, Radulović L, Pericin D. Phenolic acids in pumpkin (*Cucurbita pepo* L.) In: Victor R, Preedy, Ronald Ross Watson, Vinood B. Patel, Nuts and seeds in health and disease prevention, Academic Press. 2011; pp. 1173-1185
- [90] Provesi JG, Amante ER. Carotenoids in pumpkin and impacts of processing treatment and storage. In: Victor Preedy, Processing and Impact on Active Components in Food, Academic Press. 2015; pp. 71-80
- [91] Bombardelli E, Morazzoni P. *Cucurbita pepo* L. *Fitoterapia*. 1997; 68, 291-302
- [92] Murkovic M. Pumpkin seed oil. In: Robert A. Moreau, Afaf Kamal-Eldin, Gourmet and health-promoting specialty oils, AOCS Press. 2009; pp. 345-358
- [93] Hernandez EM. Specialty oils. In: Thomas A.B. Sanders, Functional dietary lipids, Food formulation, Consumer issues and Innovation for health, Woodhead Publishing Series in Food Science, Technology and Nutrition. 2016; pp. 69-101
- [94] Lin YC, Thùý TD, Wang SY, Huang PL. Type 1 diabetes, cardiovascular complications and sesame (zhī má). *J Tradit Complement Med*. 2014; 4(1):36-41
- [95] USDA Food Composition Database. <https://fdc.nal.usda.gov/ndb/search/list>
- [96] Sacks FM, Lichtenstein AH, Wu JHY, Appel LJ, Creager MA, Kris-Etherton PM, Miller M, Rimm EB, Rudel LL, Robinson JG, Stone NJ, Van Horn LV; American Heart Association. Dietary Fats and Cardiovascular Disease: A Presidential Advisory From the American Heart Association. *Circulation*. 2017; 136(3):e1-e23
- [97] Srisuthtayanont W, Pruksakorn D, Kongtawelert P, Pothacharoen P. Effects of sesamin on chondroitin sulfate proteoglycan synthesis induced by interleukin-1beta in human chondrocytes. *BMC Complement Altern Med*. 2017; 17(1):286.
- [98] Nandhai R, Singh H, Garg K, Rani S. Therapeutic potential of sunflower seeds: An overview.

International Journal of Research and development in Pharmacy and Life Sciences. 2014; (3):967-972

[99] Anjum FM, Nadeem M, Khan MI, Hussain S. Nutritional and therapeutic potential of sunflower seeds: A review. *British Food Journal*. 2012; 114(4):544-552

[100] Bolling BW, Chen CY, McKay DL, Blumberg JB. Tree nut phytochemicals: composition, antioxidant capacity, bioactivity, impact factors. A systematic review of almonds, Brazils, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts. *Nutr Res Rev*. 2011; 24(2):244-75

[101] Morris MC, Evans DA, Bienias JL, Tangney CC, Wilson RS. Vitamin E and cognitive decline in older persons. *Arch Neurol*. 2002; 59(7):1125-32

[102] Jaceldo-Siegl K, Haddad E, Oda K, Fraser GE, Sabaté J. Tree nuts are inversely associated with metabolic syndrome and obesity: the Adventist health study-2. *PLoS One*. 2014; 9(1):e85133

[103] Sánchez A, Vázquez A. Bioactive peptides: A review, *Food Quality and Safety*. 2017; 1(1):29-46

[104] Lemes AC, Sala L, Ores JDC, Braga ARC, Egea MB, Fernandes KF. A review of the latest advances in encrypted bioactive peptides from protein-rich waste. *International Journal of Molecular Sciences*. 2016; 17: 950

[105] Caili F, Huan S, Quanhong L. A Review on Pharmacological Activities and Utilization Technologies of Pumpkin, *Plant Foods Hum. Nutr*. 2006; 61(2):73-80

[106] Magdeleine M, Mahieu M, Archim H. Pumpkin (*Cucurbita moschata* Duchesne ex Poir.) seeds as an anthelmintic agent? *Nuts and Seeds in Health and Disease Prevention*. 2011; 933-939

[107] Shahi MM, Rashidi M-R, Mahboob S, Haidari F, Rashidi B, Hanaee J. "Protective effect of soy protein on collagen-induced arthritis in rat," *Rheumatology International*. 2012; 32(8):2407-2414

[108] Kovacs-Nolan J, Zhang H, Ibuki M, Nakamori T, Yoshiura K, Turner PV, Matsui T, Mine Y. "The PepT1-transportable soy tripeptide VPY reduces intestinal inflammation." *Biochim Biophys Acta*. 2012; 1820(11): 1753-1763

[109] Young D, Ibuki M, Nakamori T, Fan M, Mine Y. "Soy-derived di- and tripeptides alleviate colon and ileum inflammation in pigs with dextran sodium sulfate-induced colitis," *Journal of Nutrition*. 2012; 142(2): 363-368

[110] Sato K, Egashira KY, Ono S, et al., "Identification of a hepatoprotective peptide in wheat gluten hydrolysate against D-galactosamine-induced acute hepatitis in rats," *Journal of Agricultural and Food Chemistry*. 2013; 61(26):6304-6310

[111] Xue Z, Yu W, Liu Z, Wu M, Kou X, Wang J. "Preparation and antioxidative properties of a rapeseed (*Brassica napus*) protein hydrolysate and three peptide fractions," *Journal of Agricultural and Food Chemistry*. 2009; 57(12):5287-5293

[112] Malaguti M, Dinelli G, Leoncini E, Bregola V, Bosi S, Cicero AFG, Hrelia S. Bioactive peptides in cereals and legumes: Agronomical, Biochemical and Clinical Aspects. *Int J Mol Sci*, 2014; 15(11):21120-21135

[113] Nakurte I, Klavins K, Kirhnere I, Namniece J, Adlere L, Matvejevs J, Kronberga A, Kokare A, Strazdina V, Legzdina L, Muceniece R. Discovery of lunasin peptide in triticale (*X Triticosecale* Wittmack) *Journal of Cereal Science*. 2012; 56:510-514

[114] Soetan KO, Olaiya CO, Karigidi KO.
Comparative in-vitro antioxidant
activities of six accessions of African
yam bean (*Sphenostylis stenocarpa* L.)
Annals of Food Sci Technol, 19

[115] Arise AK, Alashi AM,
Nwachukwu ID, Ijabadeniyi OA, Aluko
Re, Amonsou EO. Antioxidant activities
of Bambara groundnut (*Vigna
subterranea*) protein hydrolysates and
their membrane ultrafiltration
fractions. *Food Funct.* 2016; 7,2431-2437

[116] Arise AK. Inhibitory properties of
Bambara groundnut protein hydrolysate
and peptides fractions against
angiotensin-converting enzymes, renin
and free radicals. *J Sci Food Agric.* 2017;
97.2834-2841

[117] Udenigwe CC, Aluko RE.
Antioxidant and angiotensin converting
enzyme-inhibitory properties of a
flaxseed protein-derived high Fischer
ratio peptide mixture. *J Agric Food
Chem.* 2010; 58(8):4762-4768

[118] Chakrabarti S, Jahandideh F, Wu J.
Food-derived bioactive peptides on
inflammation and oxidative stress.
Biomed Research International.
2014; 608979