www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 109-118

www.thepharmajournal.com
Received: 19-12-2022
Accepted: 24-01-2023

Deshmukh Shubham Dhondiram
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Abhay audumbarrao Sawant
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Faisal Mamoon
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Ishiqa Aneja
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Mansi Duggal
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Corresponding Author:
Deshmukh Shubham Dhondiram
Department of Food Technology and Nutrition, Lovely Professional University, Punjab, India

Nutritional characterization of pseudocereals: A review

Deshmukh Shubham Dhondiram, Abhay Audumbarrao Sawant, Faisal Mamoon, Ishiqa Aneja and Mansi Duggal

DOI: https://doi.org/10.22271/tpi.2023.v12.i3b.19413

Abstract
The adoption of healthy lifestyles and sensible eating practices are more important to consumers nowadays. Due to the increased danger of health-related issues, less and fewer species of the wide range of plants that may be utilized for human nourishment are employed today. The requirement for an increase in the nutritional content of goods made from cereals that are gluten free has been brought to light by the findings of many recent research. In order to fulfil the requirements of the expanding population to enhance diet and contribute to a better state of health, new food products are always being researched.

Keywords: Antinutritional factors, dietary fiber, functional foods, pseudocereals

Introduction
The widening gulf between population growth and food production is the biggest danger to humanity's existence. 515 million people are thought to be chronically malnourished globally, up from 777 million in 2015 but still below the 900 million threshold in 2000, according to the study The World's Food Insecurity Situation as of 2017. The amount has increased from 777 million in 2015. (2017) (Kline *et al*.) [32]. Any grain can be helpful or functional as human food, but from a nutritional standpoint, this relies mostly on how much and what kind of protein is present. One significant class of bio-macromolecules that is engaged in physiological processes is the protein family. Natural vegetable proteins are excellent building blocks since they are safe, highly biocompatible, filling, and reasonably priced. Thus, it is crucial for the food and pharmaceutical businesses to create inventive, high-amino-acid vegetable proteins. (Bergamo, Maurano, Mazzarella, Gianfrani, & Rossi, 2011) [12]. The genetic make-up of the grain and the effect of environmental conditions on its primary constituents, such as proteins, vitamins, carbohydrates, minerals, and phenolic phytochemicals, determine how well the grain functions. As a result, many cereal crops are either chemically deficient in one area or chemically rich in another. Much attention has been placed on the extraction and use of odd dietary plants, including Andes pseudocereals, in an effort to cure this illness. Because of its potential for nutrition, level of phytochemicals, and use in gluten-free goods, Andean pseudocereals are of great interest. The growth and variety of agricultural and food items are increasingly dependent on this new plant species. As these plant species have a range of health advantages, creating innovative meals from them has the potential to greatly enhance public health. As a result, the scientific community, consumers, and food manufacturers are paying increasing attention to these foods. (Behall, Scholfield, & Hallfrisch, 2006) [10] (Rave, Roggen, Dellweg, Heise & Tom Diek, 2007; Chan Wang & Holly, 2007; Slavin, 2004; Jacob & Gallaher, 2014) [61, 25, 79, 100] Despite the fact that these products are abundant in high-quality protein, amino acids, phytochemicals, and minerals, their commercialization is still somewhat constrained due to a lack of understanding regarding their nutritional makeup and a lack of cutting-edge processing and utilisation technology. In order to optimize the knowledge about processing technologies and obtain desirable functional characteristics and nutritional value, the technological range should be maintained and expanded. According to Valcárcel-Yamani and da Silva Lannes, pseudocereals are underutilised crops that are free of gluten, Rich in proteins and a variety of essential nutrients (2012). Moreover, they contain saponins, which are used in a variety of industrial and agro-pharmacological applications. The saponins can also lower blood serum cholesterol levels and have hemolytic and antilipemic activities. This function of saponins may be regarded as its most significant beneficial trait, and no evidence has been found that saponins impair protein digestion (Repo-Carrasco, Espinoza, & Jacobsen, 2003) [63].

Given the importance of the aforementioned characteristics, this review paper will broaden perspectives on the use of several under-utilized pseudocereals, for the creation of diverse pseudocereals, their nutritional qualities and potential health advantages.

Characteristics of the pseudo cereals

The American Heritage Dictionary of English defines a pseudo cereal as any plant that is not a member of the grass family but yet produces fruits and seeds that are used to make bread and other basic food items. The three best pseudocereals now available are granulated amaranth (*Amaranth caudatus*, Amaranth cruentus, and Amaranth hypochondriacus; family Amaranthceae), quinoa (Chenopodium quinoa sub sp. quinoa; Chenopodiaceae), and buckwheat (Fagopyrum esculentum; family Polygonaceae). These are dicotyledonous plants, as opposed to the different monocot cereals like wheat, rice, and barley. They are referred to as pseudo cereals because of how closely they resemble real cereals in both function and seed makeup. (2010) Arendt, Gallagher, and Alvarez-Jubete. The Andes of South America are where you may find Chenopodium quinoa Willd, the quinoa plant. The crop may grow successfully between 2000 and 4000 metres above sea level. In Hindi, the invading Chenopodium album plant is commonly referred to as "Bathua" while its English term is "pig weed" (Jan, Saxena and Singh, 2016) [92]. It may thrive in regions with limited rainfall (300-400 mm), as it is frost hardy. It produces small seeds, size varying between 1- and 2.5-mm. Quinoa may grow to a height of 1-3 m, depending on the density of the seeds. If the seed is planted deeply enough in the soil, the root might extend 30 cm. After being exposed to moisture for a few hours, the seeds might begin to develop. It had a 3.5 cm diameter, a stem that might be straight or branched, and its color could alter. It may start out being white, light brown or yellow before turning red, depending on the species. It has incomplete blooms devoid of petals and goosefoot-shaped leaves. a pericarp with two layers. After rice, it is regarded as one of the national foods of Japan main grain crop. It can be grown on almost all soil types, with the exception of sand, and prefers warm climes. It also has low humus requirements. Highly nutritive crop with one of the highest protein content rankings among plants. Both cholesterol lowering and Type-II diabetes prevention may be achieved by it. *Amaranth caudatus*, Amaranth hypochodriacus, and Amaranth cruentus are the three amaranth species that are predominantly farmed for their seeds (Kaur, Singh, & Rana, 2010) [30]. Because to its use by the Aztecs in ceremonial dinners involving human sacrifice, it was long banned from the dinner table when the Spanish conquistadors first arrived in South America (Rastogi & Shukla, 2013) [60]. The lenticular-shaped seeds are lenticular in shape and have a diameter of 1 to 1.5 mm and a weight of 0.6 to 1.3 mg (Bressani, 2003) [19]. This seed possesses a number of inherent characteristics, such as a high tolerance for dry climates and poor soils, resistance to heat, drought, and pests, as well as the capacity to thrive in environments where conventional cereal crops cannot.

Effect of pseudocereal intake on prevalence of celiac diseases

The autoimmune condition known as celiac disease (CD) is defined by a lifelong resistance to the consumption of gluten, term that also refers to the prolamins, which are certain proteins that are ethanol-soluble when stored in cereals (Kagnoff, 2005) [93]. Gluten consumption, HLA-DQ8 alleles, a genetic predisposition, and an immunological response that damages the mucosa of the small intestine and results in a total loss of Absorbtive villi are the cause of under nutrition and poor nutritional absorption. And crypt hyperplasia, which has an impact on numerous physiological systems in the body (Rodrigo, 2006) [65]. Human proteolytic digestion is unable to break down these prolamins due to their distinct amino acid composition and the large amounts of proline and glutamine residues they contain. The small intestine accumulates a range of somewhat big gluten peptides as a result of this imperfect yet partial digestion (Catassi & Fasano, 2008) [23]. Certain gluten peptides have the potential to pass through the epithelium and reach the small intestine's lamina propria. After the gluten peptides have entered the body, tissue transglutaminase can de-amidate glutamine residues in the peptides (TG). HLA-DQ2 and HLA-DQ8-expressing antigen-presenting cells showed a higher affinity for these de-amidated peptides (Silvester & Rashid, 2007) [76]. Before transmitting deamidated gluten peptides to CD4+ T cells with gluten sensitivity, these antigen-presenting cells bind them. As a result of this immune response, CD develops, which is characterized by destruction to the small intestine mucosa (Samaroo, Alaedini, & Briani, 2008; Kagnoff, 2005) [50, 93] The frequency of the condition among Americans is estimated to range from 1 in 1750 to 1 in 105. (2003) Fasano, Berti, and Gerrarduzzi. The main causes of celiac disease include gliadin, a prolamin (gluten protein) found in wheat, and other similar proteins. Tissue transglutaminase can de-amidate glutamine residues in gluten peptides once it has been internalized (TG). HLA-DQ2 and HLA-DQ8-expressing antigen-presenting cells had a stronger affinity for these de-amidated peptides. Binding deamidated gluten peptides, these antigen-presenting cells then transfer them to CD4+ T lymphocytes with a phenotype specific for gluten. This triggers an immunological response that results in CD with unique small intestine mucosa damage. It is estimated that between 1 in 1750 and 1 in 105 Americans are afflicted by the illness in the nation. Wheat and other similar proteins contain the prolamin (gluten protein) gliadin, and it is one of the primary causes of the development of celiac disease.

Serological test

In celiac disease, B-lymphocytes in the lamina propria generate anti-gluten/anti-gliadin antibodies, however these antibodies are not sensitive nor specific enough to be used as a screening tool. Even more recently, it was demonstrated that antibodies to the fibroblast-produced enzyme tissue transglutaminase (TG2) exhibited > 90% sensitivity and specificity for celiac disease. These antibodies can be found on tissue sections using endomycial antibodies (EMA) or TG2 ELISA (Capriles & Areas, 2014) [22]. Table 1 compares the sensitivity and specificity values of several antibodies for the diagnosis of celiac disease. When a disease is diagnosed, all of these antibodies, if present, are in high titers; however, when a gluten-free diet is maintained, these titers return to normal.

Table 1: Celiac disease serological testing

Antigen	Antibody Type	Test sensitivity (%) range	Specificity (%) range
Gliadin	IgA	ELISA 85	90
	IgG	ELISA 80	80
Endomysium	LgG	IFA 95	99 (97-100)
	LgG	IfA 80	97 (95-100)
Tissue	LgA	ELISA 98	96
Transglutaminase	IgG	ELISA 70	95 (94-100)
Deamidate gluten	LgA	ELISA 88	91 (80-95)
Peptide	LgG	ELISA 80	97

(Derived and modified from: Rshid & Lee, 2016; Leffler, Schuppan) [59].

IgA stands for immunoglobulin A, IgG for immunoglobulin G, and ELISA for enzyme linked immunosorbents test. IFA = Immunofluorecence asasay. Important step given that recent research indicates a small increase in this disease's mortality.

Value of nutrient-dense pseudocereals and Gluten free diets

Finding a well-balanced gluten-free diet is one of the major challenges for people with celiac disease. There are many gluten-free products on the market today, but the majority of them are of poor quality. Since they have not been thoroughly tested for gluten. network (Gul, Riar, and Mir, 2014a) [40] (Gul, Riar, and Mir, 2014a) [40] Bakery products made without gluten showed lower levels of protein, fibre, and B vitamins than those made with gluten, according to Dickey & Kearney (2006) [97] and Thompson, Dennis, Higgins, Lee, and Sharrett (2005) [87]. Thus, it is crucial to develop gluten-free bakery items with nutritional profiles that are comparable to those of their gluten-containing equivalents (Auricchio, 2012b) [8]. The capacity to restore health with a gluten-free diet has been documented by Stern, Teuscher, and Wechmann (2008) [81]. People with celiac illness still have difficulty locating gluten-free foods despite the gluten-free market's expansion. Due to their exorbitant costs, narrow selection, and inadequate sensory qualities (Mir, Gul, & Riar, 2014b) [41]. Due to these issues, People frequently find it difficult and unpleasant to follow a gluten-free diet. (Nascimento *et al*., 2014a) [45]. Rice flour is being used in place of wheat flour in some conventional recipes, according to Mohamed and Hamid (1998 Hydrocolloids, emulsifiers, and Enzymes have also been utilized in a variety of situations to improve the quality of cakes (Preichardt, Vendruscolo, Gularte, & Moreira, 2011; Ronda, Gomez, Caballero, Oliete, & Blanco, 2009; Sumnu, Koksel, Sahin, Basman, & Meda, 2010; Turabi, Sumnu, & Sahin, 2008) [55, 66, 82, 98]. inquiry into composite gluten-free bread compositions employing maize, potato, rice, and 70% sorghum flour Researchers have investigated the potential for using artificial grains into gluten-free breads. Alvarez-Jubete, Holse, Hansen, Arendt, and Gallagher (2009b) [5] compared a gluten-free bread prepared with amaranth, buckwheat, and quinoa flour to a control made with rice and potato starch (50:50). Pseudocereals improved the gluten-free bread's *in vitro* antioxidant activity as well as its levels of protein, fiber, calcium, iron, vitamin E, and polyphenols. With pseudo-cereal additions, gluten-free breads feature softer crumb textures and deeper crust and crumb colours. The feasibility of creating synthetic grains to be added to gluten-free bread has been studied by several academics. Alvarez-Jubete, Holse, Hansen, Arendt, and Gallagher (2009b) [5] compared a gluten-free bread prepared with amaranth, buckwheat, and quinoa flour to a control made with rice and potato starch (50:50). Pseudocereals improved the gluten-free bread's *in vitro* antioxidant activity as well as its levels of protein, fiber, iron, calcium, vitamin E, and polyphenols. Gluten-free loaves with pseudo-cereal added had softer crumb textures and richer crust and crumb colors. The rates of pseudoacceptance are another factor. The physical properties of gluten-free dough have significantly improved, according to studies on composite gluten-free bread formulations employing 70% sorghum flour together with maize, potato, rice, and cassava starches. Moreover, bread and bread are easily available (Onyango, Mutungi, Unbehend, & Lindhauer 2011; Schober, Messerschmidt, Bean, Park, & Arendt, 2005) [49, 70]. To find out if artificial grains may be added to gluten-free bread, studies have been conducted. Alvarez-Jubete, Holse, Hansen, Arendt, and Gallagher (2009b) [5] compared gluten-free bread made with rice and potato starch against gluten-free bread made with amaranth, buckwheat, and quinoa flour as a control (50:50). The gluten-free bread's protein, fiber, iron, calcium, vitamin E, polyphenols, and antioxidant activity are all increased *in vitro* by pseudocereals. The faux cereal-topped gluten-free loaves featured softer crumbs. The gluten-free control bread and Cereal breads have a lot of similar traits (Alvarez-Jubete, Auty, Arendt, and Gallagher, 2010c) [4]. According to Capriles and Areas (2014) [22], nutrient-dense alternative raw materials, such as non-gluten cereals, pseudocereals, legumes, nuts, seeds, and fruit and vegetable-based components, can be used to make gluten-free bread with good physical and sensory qualities and increased nutritional quality. For a rating of 6.8 on a hedonic scale of 1 to 9, the composition retained the same level of acceptability as that of the working framework and had the same amount of fiber and iron. A homogeneous crumb and increased volume were created by using the appropriate ratio of 60% popped amaranth flour to 40% raw amaranth flour. Amaranth was used as a substitute flour to create gluten-free loaves with acceptable results, and they were distinguished by their high protein, fibre, and nutritional content. Tartary buckwheat flour was used to make bread in a 2010 study by Vogrincic, Timoracka, Melichacova, Vollmannova, and Kreft. During processing, quercetin concentration increased while rutin levels dropped. The body transforms rutin into quercetin, a powerful antioxidant that may chelate metals to prevent lipid oxidation and neutralize free radicals (Boots, Drent, De Boer, Bast, & Haenen, 2011) [18]. A diet rich in these phenolic chemicals is associated with a lower incidence of oxidative stress-related disorders, such as cancer and cardiovascular disease, according to epidemiological study (Scalbert, Manach, Morand, Remesy, & Jimenez, 2005) [69]. Buckwheat, both regular and tartary, has a high protein content and an amino acid profile that is well balanced, with considerable quantities of leucine and valine. The protein content of common and tartary buckwheat is 5.84, 7.11, and 6.18 g/100 g, respectively (Bonafaccia, Marocchini,

& Kreft, 2003) [17]. According to research, buckwheat proteins can reduce blood cholesterol levels by boosting the excretion of steroids in the faeces, which results from the binding of steroids to incompletely digested proteins (Takahama, Tanaka, & Hirota, 2011, pp. 141-151) [83]. Buckwheat is nutritionally relevant, according to Skrabanja, Elmstahl, Kreft, and Bjorck, because of its dietary fiber and resistant starch content, both of which have advantages by lowering the glycemic and insulin indices (2001). While tartary buckwheat normally has similar amounts of crude protein, fiber, fat, and ash as conventional buckwheat, it is rarely ingested due to the bitter flavor that is created by its presence.

Table 2: Chemical, functional, and nutritional composition of pseudocereals

Parameter	Flour		
	Amaranth	Buckwheat	Quinoa
Physical properties			
Moisture g/100g flour	12.31±0.29	13.86±0.32	12.05±0.36
Fat g/100g flour (dry basis)	5.08±0.18 (5.79)	2.52±0.09 (2.93)	3.44±0.19(3.91)
Ash g/100g flour as is ()dry basis	1.59±0.05 (1.81)	1.67±0.09 (1.94)	2.10±0.10 (2.39)
Protein g/100g flour (dry basis)	11.00±0.23 (12.54)	13.07±0.15 (15.17)	11.32±0.16
Insoluble fibre as is (dry basis)	7.91±0.85 (9.02)	5.81±0.75 (6.74)	9.13±0.96 (10.38)
Soluble fiber	5.66±0.95 (6.45)	6.12±1.02 (7.10)	5.37±1.03 (6.11)
Total dietary fiber g/100g flour as is (dry basis)	13.57±1.4 (15.47)	11.94±1.32 (13.86)	14.5±0.98(16.49)
Digestible carbohydrates g/100g flour, (dry basis)	56 (63.86)	56 (65)	57 (65)
Functional properties			
Water holding capacity 3000 rpm g water/ g flour	1.44±0.10	1.13±0.09	1.57±0.09
Water holding capacity 5000 rpm g water/ g flour	1.05±0.05	0.8±0.09	1.16±0.06
Fat adsorption capacity, g/g	1.54±0.12	1.33±0.09	1.2±0.10
Foam capacity, mL	9±2.0	3±1.0	3±1.0
Foam stability 30, %	44±3.0	100±6.0	100±7.0
Foam stability 60, %	33±3.0	100±5.0	100±4.0
Solvent retention capacity, %			
Water	84±5.0	84±7.0	134±8.0
Sucrose	106±5.0	114±7.0	166±9.0
Sodium carbonate	99±4.0	84±8.0	140±8.0
Lactic acid	97±4.0	83±8.0	141±8.0

(Collar and Angiolony's 2014 article has been changed and adapted.)

Chemical, biological, and nutritional components of pseudo-cereals

This review paper's main points center on the usefulness and nutritional value of pseudocereals. Consumers who are concerned about their health nowadays want products with additional value, so the chance to supplement or entirely replace Cereals with better nutritional content, such quinoa, amaranth, or buckwheat, will unquestionably benefit consumers' health more than common cereal grains like corn, rice, and wheat. Pseudocereals may be the greatest choice to suit the demands of the target market due to their better nutritional profile. Table 2 lists the nutritional, functional, and chemical makeup of buckwheat, quinoa, and amaranth.

Protein content of pseudocereals

Proteins' nutritional value can be assessed based on whether they include essential amino acids that the body cannot manufacture on its own. A single amino acid deficiency will cause the other amino acids to be broken down and eliminated, which will stunt human and animal growth and eliminate nitrogen from the diet. The necessary amino acids included in protein are the most important part of it nutritionally (EAA). They must be obtained from diet since the carbon skeleton inhibits individuals from synthesizing them (Mota *et al*., 2016) [44]. As a result, the non-essential amino acids that are still present are less crucial for the establishment and upkeep of metabolic needs. A third category of amino acids is recognized as being "conditionally" necessary in addition to these two. Pseudocereals are superior to cereals in terms of protein quality and quantity. More precisely, Lysine is the limiting amino acid in grains and is widely dispersed in them. Amaranth and quinoa are fascinating for children's nutrition since they include high amounts of arginine and histidine, two nutrients that are crucial for babies and young children. According to a recent finding from our study, about 210% of the amino acids histidine, 107.33% of the amino acid isoleucine, 132.22% of the amino acid lysine, 157.72% of the amino acid methionine plus cysteine, 247.63% of the amino acid phenylalanine plus tyrosine, and 177.82% of the amino acid valine should be present in protein sources for adult nutrition (2013). Amare *et al*. (2015) [7] looked at how fermenting and popping affected things. They came to the conclusion that popping increased the amaranth's total lysine level and improved the protein content of the grains. The total lysine concentration was discovered to be greater than that of commercially available cereal grains but similar to that of legumes. Methionine and cysteine concentrations in grain proteins were greater than those in cereal and bean proteins. It is commonly known that fermentation and popping reduce the amount of foreign substances such tannin, phytate, and trypsin inhibitors. Which hinder protein digestion. Prolamins, also known as high molecular weight prolamins, are said to be the primary determinants affecting rheological qualities, according to Taylor, Taylor, Campanella, and Hamaker (2016) [85].

Carbohydrates content of pseudocereals

The primary biopolymeric component of plants, starch, is found mostly in the form of granular forms in a variety of sizes and shapes. In the human diet, starch serves as the primary source of physiologic energy, which is why it is typically categorized as a quickly accessible carbohydrate. Simple units or spherical aggregates of starchy substances can be seen in the

perisperm of the seeds. According to, quinoa contains between 67% and 74% of the dry matter in the form of carbohydrates, with a lower amylose concentration than cereals at 11%. was looked into Quinoa has starch granules that are smaller in diameter than those seen in maize earlier, according to numerous physicochemical and pasting properties (range 1-2).

Dietary fibre in content of pseudocereals

Alternative grains have gained interest recently, yet less is known about their dietary fibre content. Currently, it is believed that quinoa and dicotyledonous amaranth have beneficial nutritional qualities. as tempting foods for health. According to Berghofer and Schoenlechner's research of the total composition of the grains in 2002 [13], There is between 8 and 16% dietary fibre in amaranth grains, with 33-44% of it being soluble. Amaranth, quinoa, and buckwheat seeds in particular offer much more dietary fibre than traditional cereals, with amounts comparable to those found in such foods (Alvarez-Jubete, Arendt, & Gallagher, 2009a) [3]. Bunzel, Ralph, and Steinhart found the following sugars: Arabinose (22%), Xylose (9%), Galactose (6%), Rhamnose (4%), Mannose (2%), and Fucose (1%). (2005), followed by glucose (57%) and other monosaccharides, made up the majority of the insoluble fibre in amaranth. The amount of total dietary fibre in quinoa, according to various researchers, is comparable to that of amaranth and is comparable to those of leguminous seeds and cereal grains. In a recent study, rhamnogalacturonan-I (RG-I), a pectic polysaccharide having side chains to arabinan and galactan, was shown to make up the majority of the pectic polysaccharides isolated from quinoa seeds. Also, rats exposed to these pectic polysaccharides demonstrated protection from stomach ulcers brought on by ethanol (Cordeiro *et al*., 2012) [28]. The insoluble fibres from pseudocereals are mostly made up of homogalacturonans that are interwoven with, according to Lamothe, Srichuwong, Reuhs, and Hamaker's 2015 [34] investigation of the dietary fibre content of quinoa and amaranth. The quantities between the two grains varied significantly, with amaranth having a marginally higher quantity of soluble dietary fibre than quinoa. based on Lamothe *et al*., homogalacturonans and arabinans make up the bulk of the soluble fibre in quinoa (2015) [34]. Pectic polysaccharides, branched xyloglucans with a preponderance of disaccharide and trisaccharide side chains, and xyloglucans made up the majority of the soluble fibre in amaranth. Soluble dietary fibre in quinoa has less xylose than in amaranth. It is crucial to look into the potential physiological and functional properties of quinoa and amaranth fibres since little is known about the physiological and fermentative properties of xyloglucans and because this fibre composition differs from that of cereal fibres.

Table 3: The primary proteins for storing seeds in pseudocereals

Plant type	Protein	Fraction of total %	Main structural elements	Molecular weight of main monomer×103	Amono acid	Cysteine content (mol %)	Polymer/ monomer
Buckwheat	2s alb	25	N,D	9-16	MET,GLU,ASP	0.8	Dimeric
	13s glb	75	B-sheet	33-44	ASP,GLU,GLY	3	hexameric
Quinoa	2s alb	N,D	N,D	7-9	CYS,ARG,GLU	17	Dimeric.
	11s glb	ND	ND	321	ASP,ARG,GLU	8	Hexameric
Amaranth	11s glb	80	β-sheet	271-380	GLY,LYS,GLU	N,D	Hexameric

(Adapted and modified from Belton, Delgadillo, Halford, & Shewry, 2006; Shewry *et al*., 2002) [11, 74]

GLU stands for glutamic acid, MET for methionine, ASP for aspartic acid, GLY for glycine, CYS for cysteine, ARG for arginine, and LYS for lysine and N.D for not determined.

Table 4: Possibility of using fake cereals

Process	Products	Specific properties
Cooking	Cooked seeds	Amaranth, quinoa, and buckwheat all have cooked seeds that alter in texture as they cool.
Puffing orb popping	Popped or expanded seeds	Amaranth
milling	Whole meal flour	Amaranth and quinoa
Milling and classification Flour fractions	Protein-rich	Amaranth and quinoa after adaptation of processing parameters, buckwheat
Cooking and flaking	Flakes	Amaranth, quinoa and buckwheat
Drum drying	Pre-gelatinized flours	Amaranth, quinoa, buckwheat no Full starch gelatenization
Cooking extrusion	Cooked, expanded	Amaranth and quinoa only by blending with low fat raw material due to its high fat content
Cooking extrusion	Pre-gelatinized flours	Buckwheat-very good expansion
Germination (malting)	Sprout, malt	Amaranth, quinoa and buckwheat
Direct starch hydrolysis	Protein concentrates, glucose syrup	Amaranth, quinoa, buckwheat
Starch isolation	Isolated starch	Amaranth and quinoa

Vitamins and mineral content of pseudocereals

Quinoa and amaranth both include some soluble dietary fiber, however amaranth has a higher concentration than quinoa. Homogalacturonans and arabinans make up the majority of the soluble fiber in quinoa, according to Lamothe *et al*. The predominant components of the soluble fiber in amaranth were pectic polysaccharides, branched xyloglucans with a predominance of disaccharide and trisaccharide side chains, and xyloglucans. The soluble dietary fiber of amaranth had more xylose than quinoa did. Research into the possible physiological and functional qualities of quinoa and amaranth fibers is crucial since there is little understanding about the physiological and fermentative capabilities of xyloglucans and because this fiber composition differs from that of cereal fibers. excellent sources of essential minerals including calcium, magnesium, and iron. Amaranth was discovered to be third in

terms of mineral content, after quinoa and buckwheat. Since that osteopenia and osteoporosis are prevalent in newly diagnosed celiac patients, Amaranth seeds' high calcium content is especially important for those who suffer from the illness (Rodrigo, 2006) [65].

Fats in pseudocereals

Pseudo cereals have been shown to contain more fat than most cereal species, according to research. Unsaturated fatty acids make up a large portion of pseudocereal fat (High amount of lenolenic acid). In addition to improving insulin sensitivity, Further, lowering the risk of cardiovascular disease are polyunsaturated fatty acids (Abugoch, 2009) [1]. Deep sea fish and other marine animals' livers frequently contain the highly unsaturated open chain triterpene known as squalene, is present in substantial concentrations in amaranth. Applications for pseudo-cereal squalenes in medicine and cosmetics are common. According to Alvarez-Jubete *et al*., quinoa and amaranth have two to three times as much lipid content as buckwheat and other common grains. (2009b) [5]. A diet rich in alpha lenolenic acid (ALA) n 3 fatty acid is beneficial, according to a Simopoulos study (Simopoulos, 2001) [77]. In biological markers, fatty acids all lower inflammatory and autoimmune illnesses, cancer, osteoporosis, cardiovascular disease, and other degenerative diseases. According to Ng *et al*. (2007) [47], Quinoa and amaranth lipids are typically stable against oxidation, despite having a high fat content and degree of unsaturation. This characteristic has been associated with the tocopherols, which are found in these pseudocereals in comparably large amounts and have antioxidant characteristics.

Anti-nutritional factors

Antinutritional elements are compounds that impair the survival and performance of monogastric animals. They can be utilized to make foods that feature cereal as an ingredient and are generally found in cereals. Researchers have identified saponins, phytic acid, tannins, and protease inhibitors as the anti-nutritional components in quinoa and amaranth. All plant species have secondary metabolites, or saponins, which are natural detergents that have been glycosylated. One or more sugar chains and steroidal or triterpenoid aglycones act as identifiers for the diverse constituents. Saponins are anti-quality factors found in quinoa, according to Improta & Kellems (2001) [105], but they are also linked to some fascinating biological properties. Surface active agents (surfactants) with a strong bitter taste are called saponins. Saponins have several fascinating health advantages, such as anti-inflammatory, cholesterol-lowering, anti-cancer, and anti-microbial capabilities. Amaranth seeds only contain a small amount of saponins (0.09 percent), according to Chauhan *et al*. Because of the amaranth seeds' relatively low toxicity and saponin content, customers are unlikely to face any serious health risks. In the literature, the saponin (whole seed) ranges from 0.03 to 2.05%; however, these numbers are still lower than those of soyabeans. Washing and dehulling can both significantly reduce the amount of saponins present.

Additionally, processing can remove saponins, Nevertheless, the decrease in the was not as noticeable as the one seen after washing or dehulling. Another strategy for lowering the saponin concentration of quinoa seeds is to crossbreed so-called sweet (low saponin content) and bitter quinoa species. (High saponin content). The cultivar can be categorized as sweet if the saponin level is less than 0.11%.

Processing and applications of pseudo cereals

According to research, buckwheat is processed the closest to wheat of the three pseudocereals, however, many processing methods for amaranth and quinoa require special adaptations because of their distinctive morphological and functional characteristics. Amaranth and quinoa grains are frequently used to make savory soups, desserts, drinks, sauces, cereal, and soufflés. Amaranth seeds are typically consumed intact, whereas quinoa seeds must be dehulled to get rid of the saponins that give them their bitter flavor. Due to the significant proportion of hulls in buckwheat seeds-which contain antinutritive secondary plant metabolites-these seeds are also dehulled. The processes used to use pseudocereals are listed in Table 5. Some research has indicated

Conclusion

Pseudocereals generally have a rich phenolic phytochemical content, which may have important health benefits in addition to their excellent nutritional profile. qualities that promote health. So, in order to improve dietary diversity among individuals and maintain the biodiversity of food plants, diet should include these small grains. Buckwheat, quinoa, and amaranth were being grown for their superior nutritional profiles, according to ancient and historical data and current laboratory scientific findings, and have been given their position back by contemporary scientific procedures after being ignored in favor of old crops. The recovery of pseudocereals may be slowed down by bitter seed coat saponins, however this may not be good for their "take off" among farmers for a bigger client base. Because of this, saponins have important industrial applications in agropharmacology and cosmetics.

Conflict of Interest

The authors confirm no conflict of interest

References

1. Abugoch LE. Quinoa (*Chenopodium quinoa* Willd.): Composition, chemistry, nutritional, and functional properties. Advanced Food Nutrition Research. 2009;58:1-31.
2. Alvarez-Jubete L, Arendt E, Gallagher E. Nutritive value and chemical composition of pseudocereals as gluten-free ingredients. International Journal of Food Science and Nutrition. 2009a;60(4):240-257.
3. Alvarez-Jubete L, Arendt E, Gallagher E. Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients. Trends in Food Science & Technology. 2010a;21(2):106-113.
4. Alvarez-Jubete L, Auty M, Arendt E, Gallagher E. Baking properties and microstructure of pseudocereal flours in gluten-free bread formulations. European Food Research Technology. 2010c;230:437-445.
5. Alvarez-Jubete L, Holse M, Hansen A, Arendt E, Gallagher E. Impact of baking on vitamin E content of pseudocereals amaranth, quinoa, and buckwheat. Cereal Chemistry. 2009b;86(5):511-515.
6. Alvarez-Jubete L, Wijngaard H, Arendt E, Gallagher E. Polyphenol composition and *in vitro* antioxidant activity of amaranth, quinoa buckwheat and wheat as affected by sprouting and baking. Food Chemistry. 2010b;119(2):770-

778.
7. Amare E, Mouquet-Rivier C, Servent A, Morel G, Adish A, Haki GD. Protein quality of amaranth grains cultivated in Ethiopia as affected by popping and fermentation. Food and Nutrition Sciences. 2015;6:38-48.
8. Auricchio S. An innovative approach to measure compliance to a gluten-free diet. American Journal of Clinical Nutrition. 2012b;95(3):670-677.
9. Barba de la Rosa APB, Fomsgaard IS, Laursen B, Mortensen AG, OlveraMartinez L, Silva-Sanchez C, *et al*. Amaranth (*Amaranthus hypochondriacus*) as an alternative crop for sustainable food production: Phenolic acids and flavonoids with potential impact on its nutraceutical quality. Journal of Cereal Science. 2009;49(1):117-121.
10. Behall KM, Scholfield DJ, Hallfrisch J. Whole-grain diets reduce blood pressure in mildly hypercholesterolemic men and women. Journal of the American Dietetic Association. 2006;106(9):1445-1449.
11. Belton PS, Delgadillo I, Halford NG, Shewry PR. Review: Kafirin structure and functionality. Journal of Cereal Science. 2006;44(3):272-286.
12. Bergamo P, Maurano F, Mazzarella G, Gianfrani C, Rossi M. Immunological evaluation of the alcohol-soluble protein fraction from glutenfree grains in relation to celiac disease. Molecular Nutrition & Food Research. 2011;55(8):1266-1270.
13. Berghofer E, Schoenlechner R. Grain amaranth. In P. Belton, & J. Taylor (Ed.). Pseudocereals and less common cereals. Grain properties and utilization potential; c2002. p. 219-260.
14. Berlin, Springer-Verlag Berghofer E, Schoenlechner R. Pseudocereals overview; c2009. www.sik.se/./ Berghofer.pdf 30/01/2010.
15. Bhargava A, Rana TS, Shukla S, Ohri D. Seed protein electrophoresis of some cultivated and wild species of Chenopodium. Biologia Plantarum. 2005;49(4):505-511.
16. Bhargava A, Shukla S, Ohri D. Chenopodium quinoa - an Indian perspective. Industrial Crops and Products. 2006;23(1):73-87.
17. Bonafaccia G, Marocchini M, Kreft I. Composition and technological properties of the flour and bran from common and tartary buckwheat. Food Chemistry. 2003;80(1):9-15.
18. Boots AW, Drent M, De Boer VC, Bast A, Haenen GRMM. Quercetin reduces markers of oxidative stress and inflammation in sarcoidosis. Clinical Nutrition. 2011;30(4):506-512.
19. Bressani R. Amaranth. In B. Caballero (Ed.). Encyclopedia of food sciences and nutrition; c2003. p. 166-173.
20. Bunzel M, Ralph J, Steinhart H. Association of non-starch polysaccharides and ferulic acid in grain amaranth (*Amaranthus caudatus* L.) dietary fiber. Molecular Nutrition & Food Research. 2005;49(6):551-559.
21. Cao W, Chen WJ, Suo ZR, Yao YP. Protective effects of ethanolic extracts of buckwheat groats on DNA damage caused by hydroxyl radicals. Food Research International. 2008;41(9):924-929.
22. Capriles VD, Areas JA. Novel approaches in gluten-free breadmaking: Interface between food science, nutrition and health. Comprehensive Review in Food Science and Food Safety. 2014;13(5):871-890.
23. Catassi C, Fasano A. Celiac disease. In E. K. Arendt, & F. Dal Bello (Ed.). Gluten-free cereal products and beverages. London: Academic Press; c2008.
24. Catassi C, Fabiani E, Iacono G, Agate CD, Francavilla R, Biagi F, *et al*. A prospective, double-blind, placebo-controlled trial to establish a safe gluten threshold for patients with celiac disease. The American Journal of Clinical Nutrition. 2007;85(1):160-166.
25. Chan J, Wang F, Holly E. Whole grains and risk of pancreatic cancer in a large population-based case-control study in the San Francisco Bay Area, California. American Journal of Epidemiology. 2007;166(10):1174-1185.
26. Chauhan GS, Eskin NAM, Tkachuk R. Nutrients and anti-nutrients in quinoa seeds. Cereal Chemistry. 1992;69(1):85-88.
27. Collar C, Angioloni A. Pseudocereals and teff in complex breadmaking matrices. Impact on lipid dynamics. Journal of Cereal Science. 2014;59(2):145-154.
28. Cordeiro L, Reinhardt V, Baggio C, Werner M, Burci L, Sasaki G. Arabinan and arabinan-rich pectic polysaccharides from quinoa (*Chenopodium quinoa*) seeds: Structure and gastroprotective activity. Food Chemistry. 2012;130(4):937-944.
29. Kalinova J, Dadakova E. Rutin and total quercetin content in amaranth (*Amaranthus* spp.). Plant Foods for Human Nutrition. 2009;64(1):68-74.
30. Kaur S, Singh N, Rana JC. *Amaranthus hypochondriacus* and *Amaranthus caudatus* Germplasm: Characteristics of plants, grain and flours. Food Chemistry. 2010;123(4):1227-1234.
31. Khandaker L, Ali MB, Oba S. Total polyphenol and antioxidant activity of red amaranth (*Amaranthus tricolor* L.) as affected by different sunlight level. Journal of the Japanese Society for Horticultural Science. 2008;77(4):395-401.
32. Kline KL, Msangi S, Dale VH, Woods J, Souza GM, Osseweijer P, *et al*. Reconciling food security and bioenergy: Priorities for action. GCB Bioenergy. 2017;9(3):557-576.
33. Kupper C. Dietary guidelines and implementation for celiac disease. Gastroenterology. 2005;128(4):121-127.
34. Lamothe ML, Srichuwong S, Reuhs B, Hamaker RB. Quinoa (*Chenopodium quinoa* W.) and amaranth (*Amaranth caudatus* L.) provide dietary fibres high in pectic substances and xyloglucans. Food Chemistry. 2015;167:490-496.
35. Leffler DA, Schuppan D. Update on serologic testing in celiac disease. American Journal of Gastroenterology. 2010;105(12):2520.
36. Lemos A, Capriles V, Silva M, Areas JA. Effect of incorporation of amaranth on the physical properties and nutritional value of cheese bread. Food Science and Technology. 2012;32:427-431.
37. Li SQ, Zhang QH. Advances in the development of functional foods from buckwheat. Critical Reviews in Food Science and Nutrition. 2001;41(6):451-464.
38. Lutsey PL, Jacobs DR Jr, Kori S, Mayer-Davis E, Shea S, Steffen LM. Whole grain intake and its cross-sectional association with obesity, insulin resistance, inflammation, diabetes and subclinical cvd: The mesa study. British Journal of Nutrition. 2007;98(2):397-405.
39. Mellen PB, Walsh TF, Herrington DM. Whole grain intake and cardiovascular disease: A meta-analysis. Nutrition,

Metabolism, and Cardiovascular Diseases. 2008;18(4):283-290.
40. Mir NA, Gul K, Riar CS. Technofunctional and nutritional properties of gluten free cakes prepared from water chestnut flours and hydrocolloids. Journal of Food Processing and Preservation. 2014a;39:978-984. http://dx.doi.org/10.1111/jfpp. 12311.
41. Mir NA, Gul K, Riar CS. Physicochemical, pasting and thermal properties of water chestnut flours: A comparative analysis of two geographic sources. Journal of Food Processing and Preservation. 2014b;39:1407-1413. http://dx.doi.org/10.1111/jfpp. 12359.
42. Mohamed S, Hamid NA. Effects of ingredients on the characteristics of rice cakes. Journal of the Science of Food and Agriculture. 1998;76(3):464-468.
43. Morishita T, Yamaguchi H, Degi K. The contribution of polyphenols to antioxidative activity in common buckwheat and tartary buckwheat grain. Plant Production Science. 2007;10(1):99-104.
44. Mota C, Santos M, Mauro R, Samman N, Matos AS, Torres D, *et al*. Protein content and amino acids profile of pseudocereals. Food Chemistry. 2016;193:55-61.
45. Nascimento AC, Mota C, Coelho I, Guefão S, Santos M, Matos AS, *et al*. Characterisation of nutrient profile of quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus caudatus*), and purple corn (*Zea mays* L.) consumed in the North of Argentina: Proximates, minerals and trace elements. Food Chemistry. 2014a;148:420-426.
46. Nascimento A, Fiates GMR, Anjos AD, Teixeira E. Gluten-free is not enough perception and suggestions of celiac consumers. International Journal of Food Science and Nutrition. 2014b;65(4):394-398.
47. Ng SC, Anderson A, Coker J, Ondrus M. Characterization of lipid oxidation products in quinoa (*Chenopodium quinoa*). Food Chemistry. 2007;101(1):185-192.
48. Okarter N. In J. Bouayed (Ed.). Whole grain consumption and health of the lower gastrointestinal tract: A focus on insoluble-bound phenolic compounds, nutrition, well-being and health. IntechOpen ISBN 978-953-51-0125-3; c2012.
49. Onyango C, Mutungi C, Unbehend G, Lindhauer MG. Modification of gluten-free sorghum batter and bread using maize, potato, cassava or rice starch. LWT- Food Science and Technology. 2011;44(3):681-686.
50. Oxford: Academic Press. Briani C, Samaroo D, Alaedini A. Celiac disease: From gluten to autoimmunity. Autoimmunity Reviews. 2008;7(8):644-650.
51. Pagano AE. Whole grains and the gluten-free diet. Practical Gastroenterology. 2006;30(10):66-78.
52. Pasko P, Barton H, Zagrodzki P, Gorinstein S, Folta M, Zachwieja Z. Anthocyanins, total polyphenols and antioxidant activity in amaranth and quinoa seeds and sprouts during their growth. Food Chemistry. 2009;115(3):994-998.
53. Paśko P, Sajewicz M, Gorinstein S, Zachwieja Z. Analysis of selected phenolic acids and flavonoids in *Amaranthus cruentus* and *Chenopodium quinoa* seeds and sprouts by hplc. Acta Chromatographica, 2008;20(4):661-672.
54. Perez CM, Juliano BO. Varietal differences in quality characteristics of rice layer cakes and fermented cakes. Journal of Cereal Chemistry. 1988;65:40-43.
55. Preichardt LD, Vendruscolo CT, Gularte MA, Moreira AS. The role of xanthan gum in the quality of gluten free cakes: Improved bakery products for coeliac patients. International Journal of Food Science and Technology. 2011;46(12):2591-2597.
56. Przbylski R, Lee YC, Eskin NAM. Antioxidant and radical-scavenging activities in buckwheat seeds. Journal of the American Oil Chemists Society. 1998;75:1595-1601.
57. Qi L, Hu FB. Dietary glycemic load, whole grains, and systemic inflammation in diabetes: The epidemiological evidence. Current Opinion in Lipidology. 2007;18(1):3-8.
58. Quettier-Deleu C, Gressier B, Vasseur J, Dine T, Brunet C, Luyckx M, *et al*. Phenolic compounds and antioxidant activities of buckwheat (*Fagopyrum esculentum* Moench) hulls and flour. Journal of Ethnopharmacology. 2000;72(1-2):35-42.
59. Rashid M, Lee J. Serologic testing in celiac disease: Practical guide for clinicians. Canadian Family Physician. 2016;62(1):38-43.
60. Rastogi A, Shukla S. Amaranth: A new millennium crop of nutraceutical values. Critical Reviews in Food Science and Nutrition. 2013;53(2):109-125.
61. Rave K, Roggen K, Dellweg S, Heise T, Tom Dieck H. Improvement of insulin resistance after diet with a whole-grain based dietary product: Results of a randomized, controlled cross-over study in obese subjects with elevated fasting blood glucose. British Journal of Nutrition. 2007;98(5):929-936.
62. Real A, Comino I, Moreno MdL, López-Casado MÁ, Lorite P, Torres MI, *et al*. Identification and *in vitro* reactivity of celiac immunoactive peptides in an apparent gluten-free beer. PLoS one. 2014;9(6):e100917. https://doi.org/10.1371/ journal.pone.0100917.
63. Repo-Carrasco R, Espinoza C, Jacobsen SE. Nutritional value and use of the Andean crops quinoa (*Chenopodium quinoa*) and kañiwa (*Chenopodium pallidicaule*). Food Reviews International. 2003;19(1-2):179-189.
64. Repo-Carrasco-Valencia R, Hellstrom JK, Pihlava JM, Mattila PH. Flavonoids and other phenolic compounds in andea indigenous grains: Quinoa (*Chenopodium quinoa*), kaniwa (*Chenopodium pallidicaule*) and kiwicha (*Amaranthus caudatus*). Food Chemistry. 2010;120(1):128-133.
65. Rodrigo L. Celiac disease. World Journal of Gastroenterology. 2006;12(41):6585-6593.
66. Ronda F, Gomez M, Caballero PA, Oliete B, Blanco CA. Improvement of quality of gluten-free layer cakes. Food Science and Technology International. 2009;15(2):193-202.
67. Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA. American college of gastroenterology acg clinical guidelines: Diagnosis and management of celiac disease. American Journal of Gastroenterology. 2013;108(5):656-676.
68. Sapone A, Bai J, Ciacci C, Dolinsek J, Green P, Hadjivassiliou M, *et al*. Spectrum of gluten-related disorders: Consensus on new nomenclature and classification. BMC Medicine; c2012. http://dx.doi.org/10.1186/1741-7015-10-13.
69. Scalbert A, Manach C, Morand C, Remesy C, Jimenez L. Dietary polyphenols and the prevention of diseases. Critical Reviews in Food Science and Nutrition. 2005;45(4):287-306.
70. Schober TJ, Messerschmidt M, Bean SR, Park SH, Arendt

EK. Glutenfree bread from sorghum: Quality differences among hybrids. Cereal Chemistry. 2005;82(4):394-404.
71. Schoenlechner R, Jurackova K, Berghofer E. Pasta production from the pseudocereals amaranth, quinoa and buckwheat. Book: Using cereal science and technology for the benefit of consumers; c2005. p. 74-81 harrogate, UKhttp://dx.doi.org/10.1533/ 9781845690632.3.74.
72. Schoenlechner R, Linsberger G, Kaczyc L, Berghofer E. Production of short dough biscuits from the pseudocereals amaranth, quinoa and buckwheat with common bean. Ernahrung. 2006;30:101-107.
73. Schoenlechner R, Siebenhandl S, Berghofer E. Gluten-free cereal products and beverages. London: Academic Press ISBN: 978-0-12-373739-7; c2008.
74. Shewry PR, Halford NG, Belton PS, Tatham AS. The structure and properties of gluten: An elastic protein from wheat grain. Philosophical Transactions. Biological Sciences. 2002;357(1418):133-142.
75. Shobana S, Sreerama YN, Malleshi NG. Composition and enzyme inhibitory properties of finger millet (*Eleusine coracana* L.) seed coat phenolics: Mode of inhibition of a-glucosidase and pancreatic amylase. Food Chemistry. 2009;115(4):1268-1273.
76. Silvester JA, Rashid M. Long-term follow-up of individuals with celiac disease: An evaluation of current practice guidelines. Canadian Journal of Gastroenterology and Hepatology. 2007;21(9):557-564.
77. Simopoulos AP. Evolutionary aspects of diet, the omega-6/omega-3 ratio and genetic variation: Nutritional implications for chronic diseases. Biomedicine & Pharmacotherapy. 2001;60(9):502-507.
78. Skrabanja V, Elmstahl HGML, Kreft I, Bjorck IME. Nutritional properties of starch in buckwheat products: Studies *in vitro* and *in vivo*. Journal of Agricultural and Food Chemistry. 2001;49(1):490-496.
79. Slavin J. Whole grains and human health. Nutrition Research Reviews. 2004;17(1):99-110.
80. Souci SW, Fachmann W, Krautt. Food composition and nutrition tables. CRC Press ISBN 9780849341410-CAT#; c2000. p. 9178.
81. Stern M, Teuscher M, Wechmann T. Serological screening for celiac disease: Methodological standards and quality control. Acta Paediatrica. 2008;85(412):49-51.
82. Sumnu G, Koksel F, Sahin S, Basman A, Meda V. The effects of xanthan and guar gums on staling of gluten-free rice cakes baked in different ovens. International Journal of Food Science and Technology. 2010;45(1):87-93.
83. Takahama U, Tanaka M, Hirota S. Buckwheat flour and bread. Flour and breads and their fortification in health and disease prevention. London: Elsevier; c2011.
84. Tandang-Silvas MR, Cabanos CS, Carrazco Peña LD, De La Rosa APB, OsunaCastro JA, Utsumi S, *et al*. Crystal structure of a major seed storage protein, 11S proglobulin, from *Amaranthus* hypochondriacus: Insight into its physico-chemical properties. Food Chemistry. 2012;135(2):819-826.
85. Taylor RNJ, Taylor J, Campanella HO, Hamaker RB. Functionality of the storage proteins in gluten-free cereals and pseudocereals in dough systems. Journal of Cereal Science. 2016;67:22-34.
86. Thompson T. Folate, iron, and dietary fiber contents of the gluten-free diet. Journal of the American Dietetic Association. 2000;100(11):1389-1395.
87. Thompson T, Dennis M, Higgins LA, Lee AR, Sharrett MK. Gluten-free diet survey: Are americans with coeliac disease consuming recommended amounts of fibre, iron, calcium and grain foods? Journal of Human Nutritition and Diet. 2005;18(3):163-169.
88. Tomotake H, Yamamoto N, Kitabayashi H, Kawakami A, Kayashita J, Ohinata H, *et al*. Preparation of tartary buckwheat protein product and its improving effect on cholesterol metabolism in rats and mice fed cholesterol enriched diet; c2007.
89. Chlopicka J, Pasko P, Gorinstein S, Jedryas A, Zagrodzki P. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. LWT-Food Science and Technology. 2012;46(2):548-555.
90. Rave K, Roggen K, Dellweg S, Heise T, Tom Dieck H. Improvement of insulin resistance after diet with a whole-grain based dietary product: results of a randomized, controlled cross-over study in obese subjects with elevated fasting blood glucose. British Journal of Nutrition. 2007;98(5);929-936.
91. Chlopicka J, Pasko P, Gorinstein S, Jedryas A, Zagrodzki P. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. LWT-Food Science and Technology. 2012;46(2):548-555.
92. Jan R, Saxena DC, Singh S. Pasting, thermal, morphological, rheological and structural characteristics of Chenopodium (*Chenopodium album*) starch. LWT-Food Science and Technology. 2016;66;267-274.
93. Kagnoff MF. Overview and pathogenesis of celiac disease. Gastroenterology. 2005;128(4):S10-S18.
94. Briani C, Samaroo D, Alaedini A. Celiac disease: from gluten to autoimmunity. Autoimmunity reviews. 2008;7(8);644-650.
95. Mir NA, Riar CS, Singh S. Nutritional constituents of pseudo cereals and their potential use in food systems: A review. Trends in Food Science & Technology. 2018;75:170-180.
96. Planey AM, Smith SM, Moore S, Walker TD. Barriers and facilitators to mental health help-seeking among African American youth and their families: A systematic review study. Children and Youth Services Review. 2019;101:190-200.
97. Dickey W, Kearney N. Overweight in celiac disease: prevalence, clinical characteristics, and effect of a gluten-free diet. Official Journal of the American College of Gastroenterology ACG. 2006;101(10):2356-2359.
98. Turabi E, Sumnu G, Sahin S. Rheological properties and quality of rice cakes formulated with different gums and an emulsifier blend. Food hydrocolloids. 2008;22(2);305-312.
99. Radulovic S, Calderon MA, Wilson D, Durham S. Sublingual immunotherapy for allergic rhinitis. Cochrane database of systematic reviews; c2010. 12.
100. Jacob J. Using quinoa in organic poultry diets. *University* of Kentucky Recuperado de; c2014. http://articles extension org/pages/70244/using-quinoa-in-organic-poultry-diets.
101. Van Ham RC, Kamerbeek J, Palacios C, Rausell C, Abascal F, Bastolla U, *et al*. Reductive genome evolution

in Buchnera aphidicola. Proceedings of the National Academy of Sciences. 2003;100(2);581-586.
102. Bharti A, Singh A, Patle PK, Ansari F, Upadhyay A. Nutritional and physical properties of pseudo-cereal based geriatric food mix supplemented with moringa leaves. Journal of Pharmacognosy and Phytochemistry. 2020;9(6S):16-20.
103. Alvarez-Jubete L, Arendt EK, Gallagher E. Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients. Trends in Food Science & Technology. 2010;21(2):106-113.
104. Güçlü-Üstündağ Ö, Mazza G. Saponins: properties, applications and processing. Critical reviews in food science and nutrition. 2007;47(3):231-258.
105. Improta F, Kellems RO. Comparison of raw, washed and polished quinoa (*Chenopodium quinoa* Willd.) to wheat, sorghum or maize based diets on growth and survival of broiler chicks. Livestock Research for Rural Development. 2001;13(1):1-10.
106. Chand N, Mihas AA. Celiac disease: Current concepts in diagnosis and treatment. Journal of Clinical Gastroenterology. 2006;40(1):3-14.