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Botanical description, cultivation, and nutritional profile of ancients' grains (Quinoa, Chia, and Buckwheat) and their importance in 21st century: A review

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Abstract

The populations of emergent nations are increasing, some of them are facing food insecurity and hunger issues. Different factors i.e., elevation in the process of building up land, climate change, and rough land use are accountable for the rise in the demand of food. Due to this the demand of time to grow alternative crops such as quinoa, chia, and buckwheat, which have higher nutritive value as well as resistance behavior than traditional crops like wheat, rice, and maize to cope with hunger and food security. Then production of these different crops helps to deal with economic issue and provides various macronutrients and minute nutrients. Alternative crops i.e., quinoa, chia, and buckwheat can survive against abiotic factors (heat stress, frost, high salinity, water stress) and biotic factors (insect/pest attack, weeding) and thus provide better production. Moreover, these crops contain higher amounts of protein, minerals, fiber, carbohydrates, and lipids which play important role in diet of humanitarians. Though this review enlightens the intent of pseudo-cereals demand in present era by focusing on their competitive production to combat world insecurity of food and to increase the awareness about these crops' compositions. These crops contain high medicinal values as the patients can use the products of these crops to treat their diseases. Production of alternative crops can also play important role in country's economy.

Keywords: Alternative crops, Buckwheat, Chia, Food security, Quinoa

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Introduction

The population of emerging countries has been increasing, from which many countries are facing food insecurity and hunger issues because of different factors i.e., increases in the process of building up land, climate change, and rough land. From preceding years, many of the countries focused on improving their agricultural production, land use, and population control to somehow reduce the food demand (Grassini et al., 2013). By the year 2050, the global community is predictable to reach up to 9.6 billion people and nearly 70% or more food is required to nourish such a population than now (Tilman et al., 2002; Godfray et al., 2010; Springmann et al., 2018).

Food security states that the social, physical, and economic access to wholesome, safe, food to all individuals at any time justifies the dietary demands for a healthy and active life. There is a need to grow a variety of alternative crops such as quinoa, chia, and buckwheat which have higher nutritive value as compared to traditional crops like wheat, rice, and maize to cope with hunger and food security in the 21st century (Arslan-Tontul et al., 2022). Having biotic resistance of these crops than traditional have great impact on survival (high temperature, humidity, soil salination, cold, and drought) and biotic stress (insect and pest attack) (Jacobsen et al., 2003; Lopez-Marques et al., 2020). These are not only well taken up to stressful conditions, but also free from insect invasion and insect attack which shows their potential for organic farming. Quinoa was utilized to sustain livestock, and 2-3 thousand years ago for human ingestion in Bolivia and Peru (Prado et al., 2000). Quinoa is also designated as a "Superfood" due to its high nourishing value and can persist against 40 dS M^{-1} salinity stress, 25% of field capacity, and -4 °C temperature (Basra et al., 2014).

Besides, chia holds the high functional properties that overcome the disease probabilities of cardiovascular, obesity, and diabetes in current scenarios (Ullah et al., 2015; Ikumi et al., 2019). Because of its promising nutraceutical qualities, buckwheat can be included in the makeup of flour-based snacks. Buckwheat flour is commonly used in noodle making to assess its chemical components, cooking quality, color values, and sensory qualities (Bilgicli, 2008). These crops are not only measured as the chief source of quality protein but also the high micronutrient content, and numerous polyphenolic antioxidants that preserve the seeds by enzymatic degradation and from bacterial attack (Cahill, 2002). These crops are free from gluten and take part as an essential role in the anticipation of celiac disease (Hafeez et al., 2022). The main objective of this review is to enlighten pseudo-cereals rising need for upcoming era by growing highly nourished crops. And promote altered crops that would abiotic and biotic resistant with great nutritional profile for human health and world production.

Quinoa crop

Description of quinoa

Quinoa (*Chenopodium quinoa*) is a self-pollinated annual herbaceous plant that belongs to the amaranth family. It is largely measured as the pseudo-cereal (non-grass but used in the same way as any other cereal) and its seeds are rich source of vitamins, protein, fibers, and minerals (Graf et al., 2016). For the very first time, this crop was introduced in the Andean division near-by parts of South America for domestic purposes (Fuentes, 2010). The middle stem of the quinoa might be branched or unbranched reliant on the variety and it is extensively distributed as green, purple, and red. Quinoa is best experienced for its resistant behavior which can survive against any kind of severe environment (Navruz-Varli & Sanlier, 2016). Its seed diameter is about 2 mm which is found in various colors such as white, black, red mainly depending on its cultivars (Vaughan and Geissler, 2009).

Quinoa is grown in more than seventy countries including Pakistan, India, Kenya, the United States, and many other European countries in present times. It was introduced in 2009 in Pakistan. Because of its high nourishing value quinoa is also termed as a "Superfood". Quinoa can endure against 40 dS M^{-1} salinity stress, 25% of field capacity, and -4 °C temperature (Basra et al., 2014). The stored osmoles content in quinoa offers the osmatic modifications against the oxidative stress in the emerging leaves (Adolf et al., 2013). The positive selection of seedling personae like survival percentile of seedling and germination index can be happen related to genotypes selection based on a shoot or root length and terminal germination percentage (Munir et al., 2011). Genotypes of quinoa differ equal to seed notation (color, size, and shape), geographical origin, and main panicle type (Andrews, 2017). Different agronomic and management practices also a source of variation in grain yield, canopy growth, and physiologic maturity regarding quinoa cultivar (Hinojosa et al. 2018). Under the field environments, agronomic practices such as planting techniques (broadcast sowing, ridge sowing, flat sowing, bed sowing, and sowing in standing water) play an essential role to accomplish the targeted produce, mainly in developing crops like quinoa (Ali et al., 2020). Besides this, nitrogen is considered as the core factor which governs the yield and yield-related traits (Basra et al., 2014). The minutiae of inflorescence mostly occurred in the main shoot. Before the completion of the leaf development stage the development of inflorescence initiates and is usually not visible. In quinoa, when the elongation of leaves occurs fluorescence becomes perceptible. This stage completes when the inflorescence is exposed without being covered by the leaves, yet all its flowers are closed. The inflorescence color can be white, green, orange, red, pink, yellow, grey, brown, black, or in a junction such as white and red (Sosa-Zuniga et al., 2017). Before or after the emergence of inflorescence the side shoots can be developed mainly depending on the quinoa genotypes. The side shoot is detected to be visible when its length is 1cm or more.

Cultivation of quinoa

The peak seeding time for quinoa is mid-September to mid-November, while the mean temperature ranges from 15-25 °C. Six months of time is required to complete lifecycle of quinoa crops depending on the condition which recommends the seedling and harvesting months (Sajjad et al., 2014). According to the altitude and latitude of the origin the genotype of quinoa shows different performances. Quinoa mostly grown from coastline areas to over 4000 m in the Andes near the equator. Rainfall for the quinoa growth varies equal to cultivars, ranging from 350 to 1000 mm during its growing season. Quinoa has gained worldwide sustentation due to its resistance policies under saline and poor nutrient soil (Hinojosa et al., 2018). The maintained agronomic practices and enough nitrogen give maximum yield. In 2017, the quinoa genome was successfully sequenced by the experts at King Abdullah University of Sciences and Technology in Saudi Arabia (Jarvis et al., 2017; Golicz et al., 2020). Through genetic engineering and selective breeding, the yield is modified to attain increased yield, greater tolerance versus abiotic and biotic stress, and increasingly sweetness by inhibiting the saponin content. Quinoa harvesting is done by hand as many quinoa cultivars have hitches with the process of mechanization (Filho et al., 2017).

Quinoa nutritional profile

Related to quinoa nutritional aspects, it is way improved that the traditional crops such as one cup of cooked quinoa provides 220 calories (Ruales et al., 2002). Nearly, 100g uncooked quinoa gives 64%-68% carbohydrate, 15-16% protein, 6% fat, and 13% water. Contrarily, 100g cooked quinoa yields 21% carbohydrates, 4% protein, 2% fat, and 72% of water which is more than the wheat, barley, rye, corn, sorghum, and rice (Jancurova et al., 2009; Abugoch James, 2009). In quinoa, globulins (37%) and albumin (35%) are the reason to give composition of stored protein, but it also has the prolamin concentration in small amounts. These values can vary in different quinoa species (Abugoch James, 2009; Onwulata et al., 2010). In quinoa carbohydrates have 52-69% starch concentration. It holds sugar concentration up to 3% which is mostly maltose, D-ribose, D-galactose, and low level of glucose and fructose (Abugoch James, 2009). Quinoa is used to make different foods like soups, sauces, and flours due to its better freeze-thaw solidity, perseverance at low-temperature storage, and moderate gelling point (Vega-Galvez et al., 2010; Stoleru et al., 2022). The table related to the evaluation of the chemical composition of quinoa with other major cereals and legumes (Table 1).

Table 1 Evaluation of the chemical composition of Quinoa with other major cereals and legumes

Grains nutritional amount per 100g dry weight	Quinoa	Wheat	Rice	Maize	Barley	Bean	Lupine
Energy (Kcal)	395	393	372	406	382	366	360
Protein	16.5	14.2	7.8	10.21	10.6	28	39.1
Carbohydrates	68	78.5	80.2	81.2	80.8	61.3	35.2
Fat	6.02	2.3	2.2	4.6	1.8	1.2	7.0
Ash	3.7	2.1	3.4	11.6	2.2	4.6	4.0
Fiber	3.7	2.6	6.4	4.3	4.4	5.0	14.5

(Galwey, 1992; Ranhotra et al., 1993; Valencia-Chamorro, 2003; McKevith, 2004; Jancurova et al., 2009; Abugoch James, 2009; Miranda et al., 2010; Wu, 2015; Satheesh & Fanta, 2018).

Minerals

Minerals are present in higher amounts in external bran layer of quinoa as compared to other major grain cereals (Aguilar and Jacobsen, 2003). There are well-nigh 874 mg/kg of calcium, 81 mg/kg of iron, and phosphorus contents present in quinoa which are way higher than the barley and maize (Ahmed et al., 2019). The embryo of quinoa holds the potassium, magnesium, and phosphorus minerals; however, P and Ca are in the pericarp connected with pectic structures of the cell wall (Konishi et al., 2004). Although, sulfur is evenly diffused within the quinoa embryo. While iron is present in a soluble form which can be available to anemic groups (Valencia-Chamorro, 2003).

Protein

Different studies have terminated that quinoa contains an upper protein content between the range of 13.6% to 16.8%, with a stereotype of 15% (Koziol, 1992; Abugoch James, 2009). Sweet varieties of quinoa (having a smaller saponin amount) have a protein ratio of 14.7%, while the bitter verities of quinoa (having a high saponin amount) have a protein ratio of 15.6% (Wright et al., 2002). A study has stated that some quinoa genotypes have a protein content among the range of 12.8% to 15.2% (De-Bruin, 1963). Quinoa has double lysine content than the wheat crop. Additionally, quinoa has described higher concentrations of methionine and sulfur-holding amino acids cysteine as compared to other traditional crops (Schlick and Bubenhcim, 1996). Quinoa is measured as low gluten crop due to the low contents of glutamines and prolamines and this is the best choice to cure celiac disease (Moss and McSweeney, 2022).

Carbohydrates

The starch present in the perisperm of quinoa is known as the main polymeric carbohydrate (Antuna et al., 2003). Nearly 58% to 64.3% of dry matter comes through the starch from which 11.2% is amylose (Repo-Carrasco et al., 2003). The granules of quinoa starch are smaller than the other major crops, having a polygonal structure with a 2 µm diameter. It has incomparable freeze-thaw stability due to the presence of more amylopectin, and thus it is the best thickener in frozen materials where aversion to retrogression is required (Ahmed et al., 2019).

Vitamins

All human beings require small amount of micronutrients for endurance. Unexpectedly, quinoa has more amount of vitamin content as compared to other crops like wheat, barley, and rice (Koziol, 1992). About 100 g quinoa can provide 0.62 mg of pantothenic acid provided by palatable portion, 0.21 mg of B6 vitamin, 23.4 g folic acid, and 7 g of biotin amounts (Bhargava et al., 2006). The antioxidant properties of quinoa get enhanced because of the significant concentration of tocopherol. Quinoa contains higher beta carotene contents (0.40 mg over 100 g of dry weight) than the other major crops such as wheat (0.03 mg over 100 g dry weight), and barley (0.02 mg over 100 g of dry weight) (Koziol, 1992). Quinoa has ten times more folate content than the wheat crop (Kaul et al., 2005). So, consumers can take their requirement of vitamin from this crop.

Dietary fiber

Dietary fibers are categorized in 2 terms i.e., total insoluble and soluble fiber. According to research, these insoluble and soluble fiber contents have been found in different cultivars of quinoa (Valencia-Chamorro, 2003). The contents of soluble fiber are quite like rye, while the insoluble fiber contents are a bit lower. According to a study, the extrusion process of quinoa seeds can eliminate the bitter matter, which helps to get fiber properly (Repo-Carrasco et al., 2003).

Sugars

According to research, quinoa contains about 1.9% monosaccharides and 2.4% disaccharides (Valencia-Chamorro, 2003). There are higher concentrations of maltose and D-xylose, and low contents of fructose and glucose are present in quinoa flour. Moreover, the low fructose glycemic index is due to its contents of D-galactose, D-ribose, and maltose.

Fats

The embryo of the quinoa contains more fat content than the maize (2-4%) ranging from 1.9-9.5%, having an average of 6% (Koziol, 1992). There is about 15% of lipid content present in quinoa through around 70% unsaturated fatty acids (27.9 % of oleic and 38.7 of linolenic acids) (Dini et al., 2005). Linolenic acid is considered the richest fatty acid found in quinoa crops (Ahmed et al., 2019). In quinoa, vitamins act as a natural antioxidant that assists in the protection of all the fatty acids (Araujo-Farro et al., 2010).

Importance of quinoa in 21st century

In the Andean region, almost all production of quinoa is done by associations and local farmers. More than 70 countries in the world are doing cultivation of quinoa including the United States (U. S.), Pakistan, India, and many other regions are working on it. The quinoa prices get tripled during 2006 and 2013 because of the nutritive consumption and increased popularity in Northern America, Australia, and Europe. Pakistan is one of the countries which participated in the FAO project based on the implementation of quinoa CIP-DANIDA to prospect the quinoa potential as an alternative grain crop and food supplement. In 2008, it was introduced in Pakistan to assess the potential of this crop under different agro-climatic zones of the state (Mazhar and Bajwa, 2017; Ali et al., 2020; Basra et al., 2014).

Major cereal crops such as rice, wheat, barley, cotton, and corn are increasingly facing issues to resist in salt stressed soils and scarce water measures in a minimal environment that are more exposed to climate change (Hirich et al., 2012). Regarding to current situation, there is must need to grow such a crop that can survive against stressed conditions such as high salinity stress and drought. Furthermore, quinoa can play a keen role in eradicating poverty, malnutrition, and hunger. Due to its surviving nature, The Food and Agriculture Organization (FAO) of the United Nations (UNs) declared the "Secretarial of the International Year of Quinoa" (Bazile et al., 2016). Quinoa is also known as gluten-free crop (Graf et al., 2015). It holds all the essential amino acids, vitamins, dietary minerals, dietary fibers, iron, and zinc, making it essential and functional food for the human body. Quinoa is also chosen as the experimental crop in the National Aeronautics and Space Administration's (NASA's) support system for long-term human-engaged space flights (Schlick, 1993). Scientists of NASA want to get such crops which contain high nutrient ratio, simplicity to grow, and ease of use for the purpose to grow in outer space. Whereas quinoa is one of the essential crops which contain greater nutrient contents, easy growth, and adaptive behavior which makes it the perfect crop for outer space. On the other hand, the United Nations has announced 2013 as "The International Year of Quinoa", because of its potential for food security as well as its high nutrient content (Basra et al., 2014). The seeds of quinoa have a limited amount of saponin which causes great defense mechanism against the pathogen attack, but there is a high need to remove that saponin content before consumption (Landi et al., 2021). There are some sweet quinoa varieties available that contain less saponin content in their seeds and are considered more vulnerable to some specific pathogen attack (McCartney et al., 2019). Consumption of quinoa often reduces the blood pressure, body weight, and blood glucose level in the human body (Farinazzi-Machado et al., 2012). Quinoa availability in baby food offers enough protein and other vital elements which helps to avoid malnutrition in the kids (Ruales et al., 2002). Quinoa can be used to treat such people who suffer from celiac disease due to its high nutritional value (Onwulata et al. 2010; Stikic et al. 2012). Quinoa can also help to reduce total cholesterol, low-density lipoprotein (LDL), and triglyceride levels. It was stated that daily consumption of quinoa can fulfill all the required nutritive recommendations and can improve the health structure as it has immense commercial value (Graf et al., 2016). Quinoas have some of the extremely healthy trace nutrients which include plant antioxidants like flavonoids. Flavonoids hold multiple health benefits, two flavonoids such as kaempferol and quercetin are greatly present in quinoa (Repo-Carrasco-Valencia et al., 2010). The glycemic index is usually referring to the raised blood sugar levels, such foods which contain a high glycemic index can increase hunger and stimulate obesity (Ludwig et al., 1999). Many of the traditional crops contain a high glycemic index, while quinoa has a less glycemic index which is about 53, considered lower than other crops. Such foods which contain a greater glycemic index can cause chronic, type-2 diabetes, and sometimes heart disease (Jenkins et al., 2002).

Chia crop (Description of chia)

Chia is widely cultivated having high oil content as well as the highest fatty acid ratio (Cahill, 2005). Chia is an ancestral, self-pollinated, and annual crop that originated from the North of Guatemala and Central Mexico (Cahill & Provance, 2002). The plant can grow up to 1.8 m (5 feet 8 inches) giant, containing contrary leaves that are about 3-5 cm wide and 4-8 cm long. Its flower color might be white or purple which are usually produced in a wide range of bunches in a spikelet at the climax of each stem. Characteristically, chia seeds are small and oval with a diameter of about 1mm. The seeds are spotty-colored, white, gray, black, and brown. The seeds of the chia crop can absorb up to 10-12 times their weight in liquid when they are soaked as the seeds are hygroscopic (Keller et al., 2018). Moreover, while soaking the seeds, it creates a mucilaginous coating that provides chia-based potable a peculiar gelatinous texture. According to economic historians, it is considered as essential as maize in pre-Columbian times, evidenced by the 16th-century Codex Mendoza. Chia is considered as a short-day flowering crop that is widely grown and commercially consumed in different regions such as Australia, Colombia, Bolivia, the United States, Argentina native Mexico, and Guatemala (Coates, 1996). Other than these regions, chia was extensively utilized in pre-Columbian Mesoamerica and was valued for its religious and medical properties in addition to its culinary uses. Chia seeds play a significant role along with corn (maize), amaranth, squash, and beans for the indigenous peoples' diet. Salvia hispanica L. or Salvia columbariae are the most frequently used names of chia (Grimes et al., 2020). Chia seeds are generally small burnt ovals measuring approximately 2.3 mm × 1.4 mm × 0.9 mm (0.09 in × 0.05 in × 0.03 in) and weighing approximate 1.4 mg (0.021 gr) per seed (Ixtaina et al., 2008). They have a mottled appearance with shades of black, grey, brown, and white. The yield of chia seed varies by cultivation methods, growing conditions, cultivars type, and geographic regions. For instance, the commercial yield of chia seed in the states of Argentina and Colombia ranges between 500 and 1,250 kg ha^{-1} (Coates & Ayerza, 1998).

Farming of chia

Different shreds of evidence stated that chia seed was first consumed as food in 3500 BC and as a staple crop in Central Mexico between 1500 and 950 BC. Between 2000 and 2600 BC, the Toltecs and Toetihuacan begin the chia cultivation in Mexico's Central Valley and is considered as one of the four primary parts of the Aztec diet. Amusingly, the primary region of healthy chia propagation correlates with the area that is the Aztec's apparent origin. Different factors i.e., elevation and location are considered as key factors in the determination of the long cycle of chia (Ayerza and Coates, 2009). Though, the different regions predict the growing cycle of chia between the period of 100-150 days depending upon the ecosystems and production sites (Ayerza, 2009). The commercial production sites for chia cultivation are usually spotted in the range of 8-2, 200 m altitude. Northwest Argentina reported a period of 120-180 days from the day of sowing to harvesting, whereas the sites were located at an elevation of 900-1500 m (Coates and Ayerza, 1998). The outdated cultivars of chia have shown a lack of photoperiodic variability as well as photoperiodic sensitivity which has reduced the commercial utilization of chia seed to subtropical plus tropical scopes earlier than 2012. Now, the conventional chia lines are naturally grown and produced in mild regions at greater latitudes in the U.S. In Kentucky and Arizona, traditional cultivars of chia have shown a halt in the function of seed maturation before or after the flower set, intercepting seed harvesting (Jamboonsri et al., 2012). Because of its significant value as religious and cultural perspectives, the Spanish conqueror prohibited its cultivation in favor of foreign grains such as barley and wheat.

The nutritional profile of chia

Chia seed has variety of polyphenols and has a proteins ratio of (25-41%), carbohydrates (16-25%), fats (28-33%), ash (4-5%), beneficial fiber (18-30%), vitamins and dry matter (91-93%). Moreover, there are multiple antioxidants present in chia (Ixtaina et al., 2008). There is no toxicological and heavy metal concentration effect in chia seeds (Peiretti & Gai, 2009). Presently, chia seed is frequently utilized for bioactive compounds (Gullon et al., 2016). The protein ratio of chia seed varies between 18.9 - 21.5%, with the difference likely due to soil conditions, climate variabilities, and agronomic practices (Ayerza and Coates, 2004). In terms of health, chia seed contains extensive fiber ratios that can enhance stool volume and protect against cancer and diverticulosis (Brandán et al., 2022). Furthermore, the high rates of fiber can help in the treatment of diabetes mellitus by slowing the digestion process and releasing the glucose, as well as lowering the plasma cholesterol by improving the peristaltic movement (Table 2).

Table 2 Assessment of seed composition of several crops

Crops	Linolenic acid (ω-3) Ω3 % of total lipids	Linolenic acid (ω-6) % of total lipids	MUFAs Oleic acid (ω-9) % of total lipids	Palmitic acid (SFAs) % of total lipids	Protein %	Dietary fiber %
Chia	65%	17.5%	6.6%	10.4%	20-23%	33.5-39.5%
Sunflower	0.6%	68.4%	18.5%	6.6%	22%	9.5%
Soybean	7.9%	53.1%	23.2%	12%	35%	9.5%
Canola	9%	18.8%	64%	3.8%	0%	0%
Cottonseed	0.29%	53.1%	17.5%	24.6%	32.8%	6%

(Perez-Hidalgo et al., 1997; Orthoefer et al., 2003; Ixtaina et al., 2008; da-Silva Marineli et al., 2014; Coelho & Salas-Mellado, 2014; Ullah et al., 2020).

Protein content

Chia seeds with 20% protein have a huge potential for correcting and preventing protein-energy starvation. The amount of protein in the seed is highly sensitive to environmental and growing conditions (Timilsena et al., 2016). Chia seed has a higher protein ratio than all the other cereal crops. Another distinguishing feature of chia is that it has less or no gluten, which allows it to be digested by celiac disease patients. Chia has significant amount of nine essential amino acids (Skov et al., 1999). The weight of the human body can be maintained by consuming an extensive protein diet. The influence of low protein (5% of daily energy intake) and high protein diet (19% of daily energy intake) was studied on 113 morbidly females and males. Research shows that people who consume rich protein base diet have lost more weight (Lejeune et al., 2005). Chia seed consumption on regular basis may aid weight loss in overweight women and men, yet this fact needs more investigation. A good balance of non-essential and essential amino acids was found in the chia seed (Orona-Tamayo et al., 2015).

Fiber content

Dietary fiber is considered an essential bio component because of its potential health benefits. According to different research, it was stated that consumption of fiber can reduce the chances of severe cancer, diabetes mellitus (type 2), and heart disease (Reyes-Caudillo et al., 2008). There are around 35 to 40 g of fiber content present per 100 g of chia seeds which is a complement to 100% of the regular suggestions for the population. Whereas defatted flour contains about 35% of the fiber of which 5-12% is soluble and the remaining content is considered as the mucilage part (Mohd et al., 2012). Chia crop contains a greater fiber as compared to flaxseed, amaranth. As a result, chia seed can be utilized to prevent a variety of diseases, including diabetes and cardiovascular (Parker et al., 2018).

Minerals

Chia seed contains 5,7 and 11 times more magnesium, calcium, and phosphorus which add more power to nutrition profile. Chia has many times greater contents of phosphorus, potassium, and calcium as compared to traditional agronomic crops like wheat, oat, corn, and rice. Furthermore, it has 2.5 and 6 times the iron content of liver and spinach respectively (Beltran et al., 2020). Moreover, 100 grams of chia concentration contains macronutrients like calcium 830 mg, magnesium 332 mg, potassium 408 mg, and phosphorus 860 mg. On the other hand, micronutrients are present as selenium 55.4 g, iron 7.71 g, copper 0.934 g, manganese 2.70 g, sodium 15.8 g, molybdenum 0.2 g, and zinc 4.60 g over 100 grams of chia concentration (Ullah et al., 2015).

Fatty acid composition

The American Medical Association advises people to switch from unsaturated to vegetable oils. Food products with lower saturated fatty acids are considered the norm, and there has been a remarkable increase in the demand for such foods in recent years. Many cases of hypertension, diabetes, obesity, cardiovascular, and other health-related disorders can be attributed to the large shift from vegetable oils to unsaturated sites of oils (Shen et al., 2018). As a result of the situation, people are eating more functional foods like chia that are higher in polyunsaturated fatty acids. The positive effects of unsaturated fatty acids plus the hypercholesterolemic impact of concentrated acids are well known (Lokuruka, 2010). The extensive amounts of polyunsaturated fatty acids in chia have boosted its prominence and cultivation by multiple factors. An omega-3 fatty acid is made up of eicosatetraenoic, linolenic acid, and docosahexaenoic acid, while omega-6 fatty acid is made up of arachidonic acid and linoleic acid (Pawlosky et al., 2003). Chia seed comes with a great amount of ω-3 ALA (alpha-linolenic acid) and ω-6 LA (linoleic acid). Chia contains about 20% of ω-6 and 65% of ω-3 fatty acids on an average basis (Mohd Ali et al., 2012). The seed is considered as a superpower of omega fatty acid. The cardio protective impacts of chia seed due to docosahexaenoic and eicosatetraenoic acid (Manzella & Paolisso, 2005). Omega-3 fatty acid in chia is 80% of the olein fraction, according to the fatty acid composition. When compared to spouse chia oil, HPLC analysis showed that the nutraceutical portion had a large portion of antioxidant substances (Santini et al., 2018).

Significance of chia in the 21st century

Prostaglandins, thromboxane, and leukotrienes are considered as the essential biochemical compounds that are involved in various physiological actions and are made up of different eicosatetraenoic and Alpha-linolenic acids (Pawlosky et al., 2001). Chia seed contains the Omega-3 fatty acid which can prevent the consequences of hypertension by blocking the sodium and calcium channel (Vuksan et al., 2007). Omega-3 can play an important role in protecting ventricular arrhythmia and improving the variability in heart rate and parasympathetic tone. A meta-analysis study was performed in the present century where quantitative research has shown that high rates of alpha-linolenic acid can reduce the chances of heart failure (Geleijnse et al., 2010).

Chia seed has a high source of omega-3 acids, greater iron content, and gluten-free content (Vuksan et al., 2007; Vuksan et al., 2010). Chia has also medicinal properties such as cholesterol reduction, prevention against epilepsy and stresses, inhibition of blood clots, and immune system improvement (González-Fernández et al., 2008). The brain of the fetus and retina development can be well-developed by consuming the chia in the pregnancy period revealed by research. In a study, the topical formulation was applied to volunteers for eight consecutive weeks. 4% of chia oil was added in the topical formulation, whereas indications related to itching, skin capacitance, and water loss were regulated on a 6-points scale.

The results have shown that collective topical formulation with chia oil can advance skin hydration and lichen chronicus in all the volunteers (Jeong et al., 2010). Uncontrolled free radicals can cause oxidative damage to biochemical compounds and living organs in the human body. Oxidative stress can result in inflammation, thrombosis, arteriosclerosis diabetes, and different kinds of cancers (Kris-Etherton et al., 2002). Based on dry matter, chia seed contains a phenolic ratio of up to 8.9% (Reyes-Caudillo et al., 2008). The increased levels of phenolics in chia can be linked with the availability of chlorogenic acid, caffeic acid, and quercetin. According to Uribe et al. (2011), chia seed is a credibly rich source of antioxidants, and it has high antioxidant value used to improve health and to preserve the food lipid system. Based on different studies, it was found that caffeic acid, quercetin, chlorogenic acid, and kaempferol can be isolated by using chia seed (Ayerza and Coates, 2001). An extensive amount of phenolics compounds were found in chia seeds (Munoz-Hernandez, 2012). Serpen et al. (2012) has described that chia seed contains strong in-vitro antioxidant activity. A study has investigated that the activity of antioxidants in the extract form of ethanolic chia seed can significantly suppress the free radicals found in the system of beta carotene linoleic acid (Tepe et al., 2007).

Chia seed has higher scavenging action of free radicals in contrast to many other sources of naturally strong antioxidants. This shows that chia seed has higher antioxidant activity as compared to Moringa Oleifera (Nadeem et al., 2013). Because of the polyphenol's presence, oxidative deterioration can be protected in chia seeds (Rahman, 2017; Nadeem and Imran, 2019). This research used the HPLC technique to characterize the phenolics in chia seed, finding that it has a significant amount of quercetin, caffeic acid, chlorogenic acid, glycoside Q, and glucoside k (Azeem et al., 2015). According to Reyes-Caudillo et al. (2008), chia seed supports a variety of antioxidants that can be considered as a good source of antioxidants. The phenomenon of lipid peroxidation can be inhibited through the chia seed's phenolics (Tepe et al., 2007).

Buckwheat Crop

Depiction of buckwheat

Buckwheat (F. esculentum Moench) is a biennial plant that survives in colder climes. The plants are erect to ascend and develop to a height of 20-80 cm. The stems are glabrous and papillae from one end and green to scarlet with a reddish tinge when mature. Leaves with a membrane ocrea and an ocrea diameter of 2-8 mm, a conical form, and a brown tint. The petiole is 2-6 cm long, with papillae throughout both sides of the veins, undulate to sagittate to truncated bases, and acuminate apices. The lamina is 2.5-8 cm long and 2-6 cm wide, with papillae throughout both sides of the veins, undulate to sagittate to truncated bases. The peduncles are around 2 to 3 mm long, the leaves are green and rectangular and about 2.5 to 3 mm wide, and each peduncle contains 3–5 pedicellate blooms with a white and pink perianth, stamens that are 0.5-fold greater than the perianth along with pinkish anthers. 1.5 to 2 mm heterostylous styles, a cheese is slightly larger than those of the Perinat, measuring 5-6 mm long. They feature obtuse angles, solidly trigonous, ovoid in shape, and are dark brown (Awan and Keswani, 2021). Buckwheat is a seeded plant with a grain-like appearance that is extensively utilised as a field crop. The taproot of the buckwheat plant penetrates deep into the damp soil and serves as the plant's root system. It can grow to be between 80-120 cm tall (Bjorkman and Shail, 2013). Buckwheat produced white seedlings and triangular seeds, while buckwheat contained yellow or pink seedlings. It contains free branches instead of suckers or tillers, which allows it to adapt to the environment better than other cereal crops. The seed hull may be easily separated by floating it apart because it has a lighter density than water (Wrigley et al., 2015).Buckwheat is primarily farmed for grain purposes as it has a short growing season (Bjorkman and Shail, 2013). Buckwheat has a 10-12-week growth cycle and can be grown in northern regions or at high elevations. Buckwheat is utilized as an organic manure for food, erosion prevention, and wildlife cover on occasion (Bjorkman and Shail, 2013).

Cultivation of buckwheat

Buckwheat is largely grown in the northern latitudes and to a smaller extent in the southern. The taxon Fagopyrum is thought to have originated in Asia, rising feral buckwheat all across Siberia and Manchuria (Morris, 1948), organically occurring within South Europe, Central Asia, China, India, and the Himalayan crags of Pakistan (Ohnishi, 1998;), and now fused in a variety of regions around the world; grown in Russia, Australia, Sikkim, Mongolia, Nepal, and In Pakistan's varied geographical areas, the genus Fagopyrum has around four species (Liu et al., 2008; Tang et al., 2010; Zhang et al., 2017).

Nutritional and biochemical properties

Flavonoids, the highest proportion of naturally produced compounds, appear to be prevalent in plants. Flavonoids are commonly present in plants' seeds, flowers, leaves, and bark. Numerous flavonoids can be found as glycosides of flavonoids in nature. Quercetin, Rutin, and robinin are some of the most common flavonoid glycosides found in food. Rutin-containing leaves and seeds were classified as nutritional supplements. Rutin is found in a wide variety of plants, however it is exceptionally rare in edible rutin sections. Rutin is a necessary ingredient in buckwheat and has been detected in a variety of plant components (Kreft et al., 2006).

Carbohydrates

Amylose concentrations in buckwheat granules range from 15% to 52%, and they aid in extending polymerization, which varies between 12 to 45 starch units. Buckwheat's principal carbohydrate is starch, which has a dry matter content of 65 to 75% and has a variety of sticking qualities. High amount of starch is available in buckwheat crops (Dziedzic et al., 2012)

Protein

Crude protein content varies from 7-21% in buckwheat based on growth conditions and varietal characters. Buckwheat contains the second highest protein ratio after oat flour and they have greater protein contents than the major cereal crops i.e., wheat, corn, sorghum, rice, and millet. The protein composition of seeds varies greatly between regular and Tartary types (Guo et al., 2007). Furthermore, there is a lot of variation in the overall chemical makeup of treated buckwheat seed components (Kreft et al., 2006). The protein content of flours ranged from 4.4 to 11.9%, with some cultivars produced in natural environments in Canada having a higher protein content (13-14%) on dry basis (Ahmed et al., 2019). Buckwheat flour and groats are great additions to high-protein loaf and cereal recipes. Buckwheat proteins seem to be the most efficient in decreasing cholesterol levels of any crop protein.

Lipids

Total lipids in regular buckwheat varies from 1.5 to 3.7%. Overall lipids in different kinds of common buckwheat range from 2.6 to 3.2%. Archive, lignoceric, plamtic, stearic, behenic, linolenic, and oleic acids are the major fatty acids found in healthy buckwheat (Ahmed et al., 2019).

Minerals

Seeds of buckwheat are excellent sources of different vital nutrients. Buckwheat contains greater amount of zinc, copper, and potassium, manganese than rice, wheat and corn (Ikeda, 2002). The mineral composition of buckwheat products can be affected by genetic and abiotic variables in general. Furthermore, it noticed that most of the Zn in buckwheat flour is created during the catalytic digestion process. Buckwheat seeds are high in several important nutrients. Manganese, copper, iron, zinc, and selenium are abundant in the grains of buckwheat (Ikeda, 2002).

Fiber

Fiber appears to be linked to a lower risk of type 2 diabetes. According to a study, buckwheat seeds contain a significant amount of dietary fiber. The fiber content in coarse grain flour is 4 to 10 times that of refined flour. It is also carried out to reduce diabetes and obesity because of its high soluble dietary fiber content.

Importance of buckwheat in 21st century

The use of buckwheat as a diet has resulted in the production of a variety of culinary and industrial items. Buckwheat is used as a feedstock or a key ingredient in a wide range of goods, including souses, soups, sweets, pasta, griddlecakes, and buckwheat wine (Kreft et al., 2006). Buckwheat flour has been used in a wide range of baked goods. It is frequently blended with some other grains in European countries. Buckwheat flour have both functional and nutritional advantages, primarily in the formulation of higher-quality gluten-free products such as pasta, cakes, bread, mac, and cheese, and has proven to be an excellent option for a balanced diet as well as a bakery product with added value and advertising effectiveness. In Asia and Europe, buckwheat mixtures were utilized to make commercially viable traditional home items (Choy et al., 2013). Gluten-free cereals, breadmaking, beverages, and a variety of other items were also advised. Buckwheat honey has traditionally been used as a sweetener alternative in everyday foods to boost antioxidant capacity and preserve DNA from harm (Capuani et al., 2014).

The use of SDS to assess buckwheat diversification in the Himalayas has been extensively studied. Limited data is available on the inherited wealth and heterogeneous nature of several buckwheat structural proteins throughout various locations, along with their intra-varieties. Genetic information and evolutionary relationships among distinct Himalayan buckwheat germplasms were assessed using molecular methods such as RAPD profiles and SDS-PAGE. According to SDS-PAGE research, there is a lack of understanding about Pakistani indigenous germplasms for common buckwheat, particularly in the Karakoram and West Himalayas regions (Hussain et al., 2018). Buckwheat is the only alternative crop grown in Gilgit-Baltistan, province of Pakistan. In Baltistan, there appears to be a lack of research information and documents on local buckwheat strains. Buckwheat cultivation has declined in this region for a variety of causes, considering geographical, social, environmental, and shifting lifestyle choices. The finding of prospective buckwheat cultivars by molecular, biochemical, and agro morphological characterization will support future breeding initiatives and buckwheat management. As a result, studying the indigenous inbred lines found in these areas is crucial. Furthermore, this extensive buckwheat assessment was truly revolutionary in this field.

Conclusion

This is the need of the hour to grow substitute crops that contain better nutritional values as compared to traditional crops to compete with food availability issues. In recent times, staple foods such as rice and wheat have been harmed by temporary climate variabilities and they are less produced. In these scenarios, there is need to grow low-cost and high-performed nutrient-dense food crops like quinoa, chia, and buckwheat that can fulfill the food demand. These alternative crops are rich in protein, carbohydrates, minerals, and vitamins. On the other hand, these crops can survive against different kinds of stresses and help to combat different food variety issues and economic conditions. Therefore, to gain benefit at world production level and fight against anti-immunity disaster these pseudo-cereals have great impact to improve profiles of health. Moreover, their production needed to regain their regime for the present era for solving malnutrition, food hunger and insecurity.

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