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Research Article

Quinoa (*Chenopodium quinoa* Willd.) is a highly Nutritious Source of Grains

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Abstract:

The main objective of this paper is the chemical evaluation of quinoa seeds (*Chenopodium quinoa wild*). The chemical composition, mineral content, active compounds (polyphenols, flavonoids, and tocopherols), vitamins, amino acids, and fatty acids of quinoa seeds were estimated. The results obtained indicate that quinoa seeds are rich in bioactive compounds, most importantly phenolic compounds, flavonoids, and vitamins, which are effective in preventing many diseases. Therefore, quinoa seeds are considered a high-nutrition alternative to grains.

Key words: quinoa seeds; bioactive components; amino acids; fatty acids

Introduction

Over the last few decades, food and food ingredients have had a significant impact on human health, making contemporary healthy lifestyles change significantly. There is a growing belief among consumers that food directly affects their health by preventing disease and improving physical and mental well-being (Samec ˇ *et al.*, 2019). The consumer has opted to change their eating habits and choose foods that, besides being a good source of nutrients, are also rich in bioactive compounds with health benefits (Betoret *et al*., 2011and Barbé *et al*., 2014).

Cereals remain the most significant source of food in the world, both for human consumption and indirect use in livestock production. However, the use of cereals for bioethanol production is increasing. (Cassman and Liska, 2007 and Pimentel *et al*., 2009). Cereals hold roughly half of their market share for feed, while the remaining 40% is for food/human consumption, 19% is for seed production and other uses, and 3% is for bioethanol. (Siegel and Babuscio, 2011).

Among the many issues facing global agriculture are food shortages and population increase. The demand for food will increase as there is a possibility of more than 10 billion people on the planet by 2050. (Tilman *et al*., 2011). Agriculture yields and growth are affected by the warming temperatures and effects of global climate change. (Jaikishun *et al.*, 2019).

So, Quinoa (*Chenopodium quinoa* Willd) is considered one of the crops that have recently attracted more attention. (Navruz-Varli and Sanlier, 2016). Also, it is considered a multipurpose agricultural seed-producing crop. Bakery products use their seeds and flour as food ingredients due to their high nutritional value. (Repo-Carrasco Valencia *et al*., 2010b). Quinoa is part of the Dicotyledonae class, Chenopodiaceae family, which also includes spinach and beet, the Chenopodium genus, quinoa species, and its name in Latin is *Chenopodium quinoa* Willd (Maradini Filho *et al*., 2015 and Tanwar *et al*.,2019). As a result, it is widely utilized as a nutritious food. It is referred to as a "superfood "or "the Golden Grain," Singh, (2019). Superfoods are products similar to traditional foods but have proven physiological benefits. Superfood consumption can help individuals improve their health and decrease the risk of diseases (Al-Sheraji *et al*., 2013); therefore, the demand for these products has been increasing these days. (Vieira da Silva *et al*., 2016).

Quinoa (*Chenopodium quinoa* Willd.) is an ancient crop that can play an important role in worldwide food security. According to the Food and Agriculture Organization (FAO), quinoa is a promising plant for humanity, due to its high nutrient value and genetic diversity. Due to its contribution to food security, Quinoa has been described as "the grain of the twenty-first century" (FAO, 2011).

The United Nations declared the year 2013 as the "International Quinoa Year" to recognize its significant potential and increase interest in this plant (FAO, 2011; FAO, 2014 and Tang, *et al*. 2015b). Quinoa contains high-quality proteins and a balanced essential amino acid composition, with an abundance of sulfur-rich amino acids. It is a great source of minerals like calcium, iron, and zinc, vitamins, and fibers, along with carbohydrates, lipids, and a low glycemic index. (Vega-Galvez *et al*., 2010 and Gordillo-Bastidas *et al*., 2016). In addition to that, Quinoa has been used by the National Aeronautics and Space Administration (NASA) due to its versatility in meeting the needs of humans during space missions (González,2014 and Cooper,2015).

Thus, the current investigation has the objective of studying comprehensive chemical analysis of quinoa seeds to confirm their high nutritional value and evaluate them from a nutritional perspective.

Materials & Methods

- *Source of quinoa seeds*: Quinoa seeds used in this study were purchased from Desert Research Center, Cairo, Egypt.

- *Solvents and reagents:* All solvents used throughout the whole work were analytical grade and distilled before use. Caffeic acid (98%) and Folin-Ciocalteau reagent were purchased from Sigma-Aldrich (St. Louis, MO, USA) and Gerbsaure Chemical Co., Ltd., Germany, respectively.

- Nutritional Value. Moisture, protein, carbohydrates, lipids, fibers, and ash contents of quinoa seeds were expressed on a dry weight basis, and the results were presented in g/100g. Analyses were carried out in three replicates and were determined by following the methods as described in **AOAC (2016).** Carbohydrate was calculated by difference.

- Fatty acids composition: Capillary gas chromatograph (HP 6890) was used for the qualitative and quantitative determinations of fatty acids of the quinoa seed oil and reported in relative area percentages. Fatty acids were trans esterified into their corresponding carboxylic acid methyl esters by shaking an amount of oil (0.1g) in heptane (2 ml) with a solution of methanolic potash (0.2 ml, 2N). The carboxylic acid methyl esters were identified employing a gas chromatograph equipped with DB-23 (5%–cyanopropyl–methyl poly siloxane) capillary column (60 m x 0.32mm X0.25µm film thickness) and flame ionization detector. Nitrogen flow was 0.6ml/min, hydrogen and air flow rates were 45 and 450ml/min, respectively. The oven temperature was isothermally heated to 195˚C. The injector and therefore the detector temperatures were 230˚C and 250˚C, respectively. Carboxylic acid methyl esters were identified by comparing their retention times with a known carboxylic acid standard mixture. Peak areas were automatically computed by an integrator. All GC measurements for every oil sample were made in triplicate, and therefore, the averages were reported.

- Determination of total polyphenolic: The levels of total polyphenols of quinoa seeds were determined according to the method of **Žilić *et al.*, (2012).** Caffeic acid was used as a standard compound for the preparation of the calibration curve.

Determination of the total flavonoids: The total flavonoid content of the quinoa seeds was determined by the aluminum chloride test (**Kim *et al.*, 2006**) using quercetin as a standard, and the results were calculated as mg quercetin equivalent/Kg of extract (mg QE/Kg).

Determination of Tocopherols: Tocopherols were determined in quinoa seed powder according to Annunziata *et al*.,2012).

Determination of Vitamins: Ten grams of quinoa seeds powder was weighed, homogenized in the mortar with a pestle, transferred into a conical flask and 25 mL of the extraction solution (made by mixing 50 mL of acetonitrile with 10 mL of glacial acetic acid and the volume was finally made up to 1000 mL) was added. The prepared solution of quinoa seed powder was injected into the HPLC using an autosampler to determine water-soluble vitamins. (Hasan *et al*.,2013).

- Mineral content: Mineral content by using atomic absorption (NC.9423-400-30042), England of the spirulina algae was determined according to the method techniques described by **(AOAC, 2016).**

- Amino acid analysis: The protein quantification was done with the micro-Kjeldahl method. Amino acid analysis procedure involves acid/alkaline hydrolysis, separation by cation exchange column, post-column derivatization with Ninhydrin, and detection using UV/V is detector at 570 nm as described in the **A.O.A.C. (2016).** The data from three independent samples were expressed as the mean value ± standard deviation.

Results & Discussion

The chemical composition and Total Energy of Quinoa Seeds (QS) were determined (dry weight), and the obtained results are presented in Figure 1. The moisture, ash, protein, fat, fiber, and total carbohydrate(mg/100mg) were 11.91, 13.01.01, 6.00, 6.11, and 71.67%, respectively (Figure 1). Also, the total energy of Quinoa seeds recorded 402.545 K.cal/100g.

Quinoa is recognized as a superior source of vegetal protein (12–23%); its protein content is similar to milk protein content and higher than that of real cereals like wheat, maize, and rice (Zannini, 2018).

According to Martínez-Villaluenga *et al*. (2020), the proximate analysis of quinoa seeds. The water, protein, lipids, and total carbohydrate were **8.2-13.1,9.1-16.7,4-7.6** and **48.5-77.0**, respectively are in the same range as our results.

The above-mentioned data could be compared with those of Abdelshafy, (2022b), who found higher contents of protein (14.40) and fat (6.88). In contrast, moisture (8.90), fiber (5.12), ash (2.63), and carbohydrates (62.07) were lower than our results.

Thus, the chemical and nutritional composition of the quinoa seeds is directly impacted by the lack of adaptation to regions that are very different from those where the cultivar originated (Valeri *et al*.,2022).

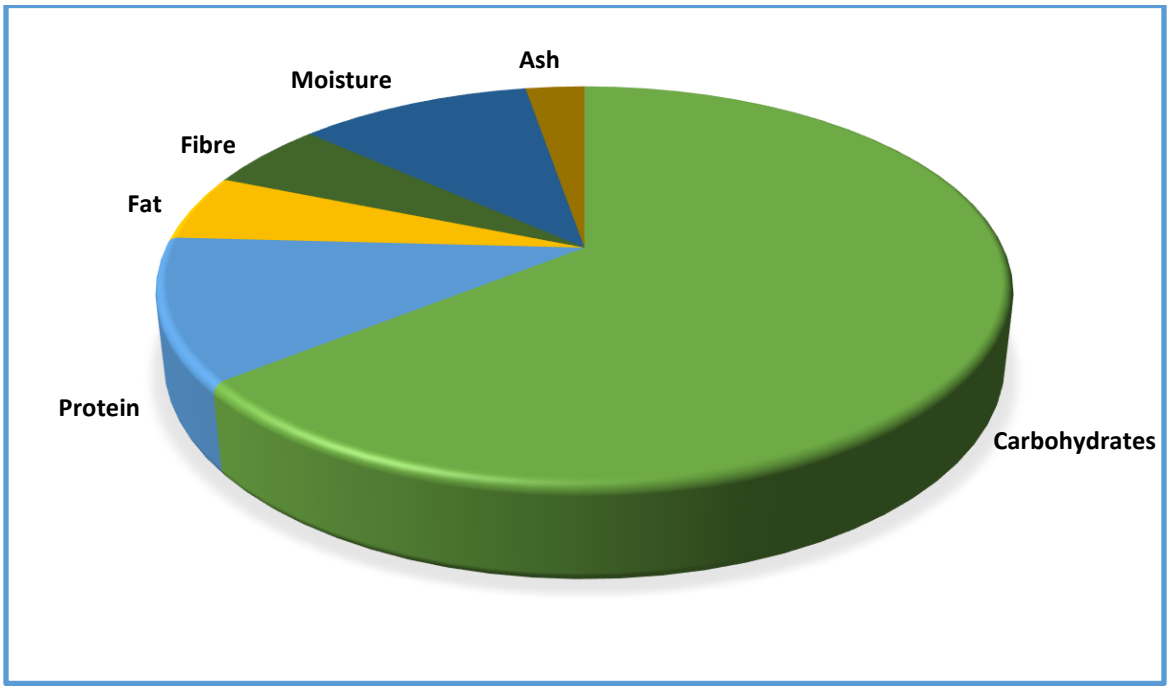

Figure 1: Chemical Composition (%) of Quinoa Seeds

Compared to other common grains like rice, corn, and wheat, quinoa has a higher ash content. The high concentration of minerals, such as calcium, magnesium, and potassium, is justified due to their bioavailable forms. (Nowak *et al*., 2016; Angeli *et al*.,2020). Quinoa has a total mineral content of 3.4%, and its seeds are rich in calcium, magnesium, iron, manganese, copper, potassium, sodium, zinc, and other nutrients (Mohamed Ahmed *et al*., 2021).

Minerals are regarded as essential elements for sustaining a healthy physiological response. In the embryo of quinoa, there are minerals like phosphorus, potassium, and magnesium. while Ca and P in the pericarp are associated with pectic compounds of the cell wall. (Konishi *et al*.,2004) Various minerals, including macro (Ca, K, Mg, and P) and microelements (Fe, Zn, and Mn), were determined in quinoa seeds (Figure 2). Dev and Gupta (2024) reported the following mineral composition (mg/100 g) of quinoa Whole: Ca (232), P (189), K (414), Mg (115), and Fe (6.9). Based on the present study, quinoa seeds are rich in Calcium, Iron, Potassium, and Magnesium. Also low in Phosphorus. This shows that the present study of quinoa seeds can serve as a valuable source of essential minerals while maintaining their nutritional benefits. Microelements such as (Mn, and Zn) were reported in quinoa seeds 24.07 ± 0.23 mg/kg,28.08 ± 0.35 mg/kg) by (Bolanos ˜ *et al*., 2016). From that, our results show average concentrations higher than other papers.

The differences in mineral content observed between this study and previous reports can be attributed to the use of different cultivars and environmental growth conditions.

The presented data in Figure 2 illustrate the mineral contents and daily values of quinoa seeds. quinoa seeds have a higher content of minerals such as (K:834, Ca:653, Mg:330, Na:170, P:119 mg/100g). These contents represent (119.14,124.38,78.57,48.57,17%) of the recommended daily intake of these minerals, respectively. The opposite situation was observed for both Zinc, iron, and Manganese (43.0,15.50,4.06), respectively. These contents represent (614.29,140.90,176.52%) of the recommended daily intake of these minerals.

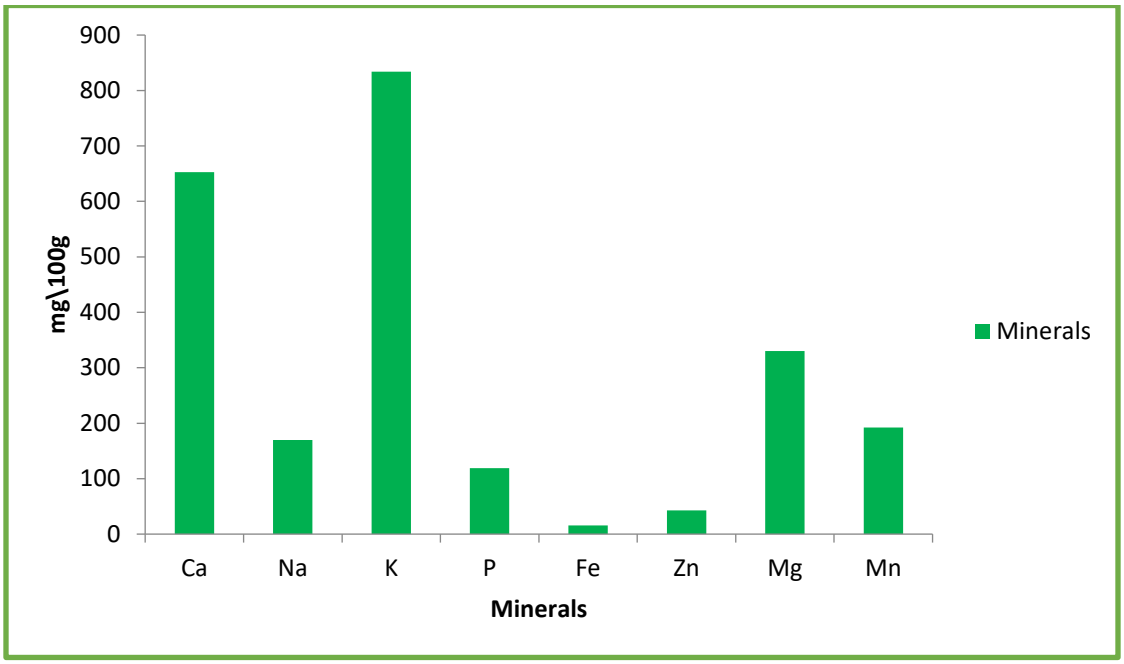

Figure 2: Mineral composition in quinoa seeds (mg/100g) and Daily Value (% of RDI) of quinoa**.**

Bioactive compounds are secondary plant metabolites with therapeutic potential (Chen *et al*., 2018; Hussain *et al*., 2021).

Quinoa seeds have a fine quality of nutrition, such as bioactive substances, with high antioxidants, which include polyphenols, tocopherols, and flavonoid compounds that are superior to those found in common grains for their health benefits, such as preventing chronic diseases. Interestingly, quinoa seed coat color appears to contribute to antioxidant activity due to the content of flavonoids (Pedrali *et al*., 2023).

The data in Figure 3shows the most essential phytochemicals in quinoa seeds (ppm), and the total polyphenols present in quinoa seeds were 455.00 ppm. Most secondary plant metabolites that result in various functional characteristics are composed of phenolic compounds, mostly in the seed coat of quinoa seeds (Liu *et al*., 2021).

It is believed that the seeds of Quinoa contain the highest concentration of ferulic acid and quercetin, and it has more phenolic compounds than whole grains. (Gordillo-Bastidas *et al*, 2016). Because of their connection to fibers, the biological effects of phenolic materials have been of recent interest to scientists. The highest rates of a-glucosidase and a-amylase inhibition of bound phenols during digestion have been shown to lower blood sugar (Suriano *et al*., 2018; Liu *et al*., 2021). Total flavonoids and polyphenols in quinoa were measured by RepoCarrasco-Valencia *et al*. (2010), who discovered that the polyphenols were 131.8 ± 10.3 mg 100 g^{-1} and flavonoids were 62.07 ± 5.1 mg 100 g^{-1}. A high concentration of total tocopherol (vitamin E) (505 ppm) is a characteristic of quinoa. The most prevalent tocopherol in quinoa seeds was γ-tocopherol (330 ppm), followed by α-tocopherol (49 ppm) and β-tocopherol (20 ppm). The fatty acids in the cell membrane are protected from oxidative stress by the tocopherol content of quinoa, which acts as an antioxidant at the membrane layer. According to quinoa seed phytochemical content values, the use of quinoa as a natural antioxidant is crucial for preventing degenerative and chronic illnesses (Liu *et al*., 2021).

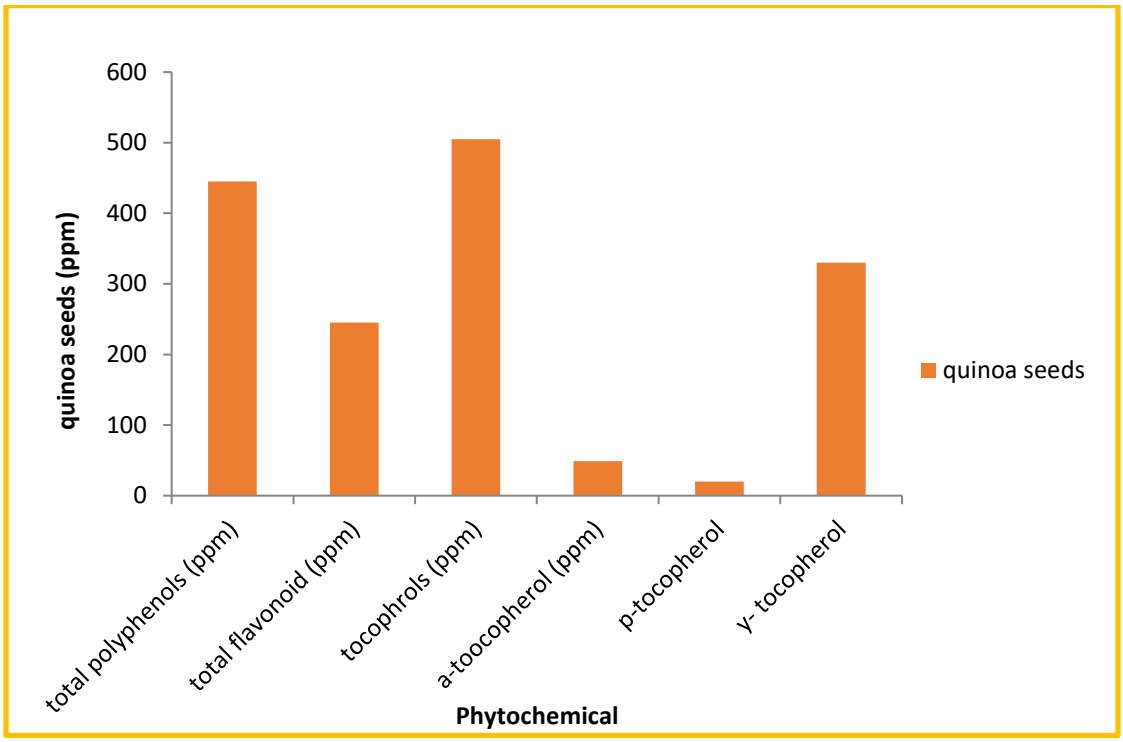

Figure 3: Phytochemical composition of quinoa seeds (ppm).

Vitamins are trace organic substances that humans need to obtain from food to maintain normal physiological functions. It plays an important role in the process of human growth, metabolism, and development. Figure 4 shows the number of certain vitamins. Vitamin B1 (VB1), also known as thiamine, is involved in carbohydrate metabolism. Quinoa seeds are rich in vitamins, which are essential compounds for human health. Compared to common cereals like wheat, barley, and rice, quinoa seeds have a significantly higher vitamin content. (Miranda *et al.*, 2012)

According to Figure 4, each 100 g of quinoa seeds has 9.90 mg of vitamin C, 14.99 mg of ergocalciferol, and 60.00 mg of vitamin A in the form of carotenoids. Niacin, essential for physical well-being, was present at (0.95 mg/100 g), vitamin B1 was (1.10 mg/100 g), and vitamin B2 was (2.50 mg/100 g). Additionally, each 100 g of quinoa seeds includes (0.43 mg) of vitamin B12, absent from cereals, (6.10 mg) of vitamin B5, (0.42 mg) of pyridoxine, and (6.25 mg) of folic acid. The basic minerals needed for the metabolism of the majority of known living things, are vitamin C (1.93 mg/kg), vitamin B3 (0.15 mg/kg), vitamin B6 (11.22 mg/kg), and vitamin B12 (0.09 mg/kg), are all abundant in quinoa flour, according to Sohaimy *et al*. (2018). So, eating quinoa helps avoid viruses and diseases.

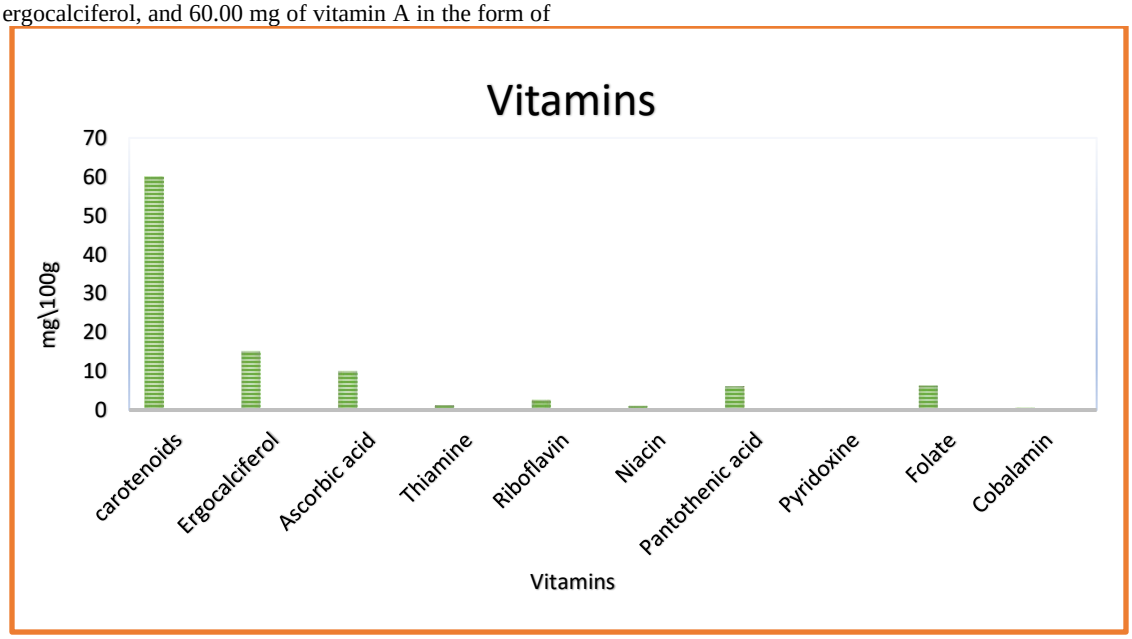

Figure 4: Vitamins in quinoa seeds (mg/100g).

Amino Acids	Quinoa Seeds

Essential Amino Acids (EAA)	
Tyrosine	2.89
Phenylalanine	1.02
Total aromatic amino acids	3.90
Threonine	2.35
Cystine	9.27
Methionine	4.35
Total sulfur amino acids	15.95
Leucine (LEU)	4.29
Isoleucine (ILE)	2.01
Lysine (LYS)	5.78
Valine (VAL)	2.70
Tryptophan	1.12
Total Essential	35.77
Non-Essential Amino Acids(NEAA)	
Aspartic	8.28
Glutamic	20.07
Proline	ND
Serine	5.33
Glycine	15.33
Alanine	6.56
Arginine	5.12
Histidine	3.65
Total non-essential	64.32

Table 1: Amino acid composition of quinoa seeds (g/100g quinoa).

Quinoa has high amounts of amino acids, limited to wheat and corn; these include lysine, methionine, and threonine (Nowak *et al*., 2016).

Patients with celiac disease can benefit from the consumption of gluten-free cereals, which makes pseudocereals a safe alternative food for them. Compared to quinoa, the Chenopodiaceae family has amino acid types and contents that can fulfill adult human dietary amino acid requirements without needing food supplementation (Xu *et al*., 2020; Zhao *et al*., 2021). Data in Table 1 shows the amino acid composition of quinoa seeds. The data obtained illustrated that the total essential amino acid of quinoa seed was 35.77 g/100 g sample, and the total non-essential amino acids were 64.32 g/100 g.

(Pathan and Siddiqui, 2022) said that all essential amino acids are present in higher concentrations in quinoa seeds, such as methionine, valine, lysine, isoleucine, histidine, threonine, phenylalanine, tryptophan, and leucine. also, non-essential amino acids are (glutamic acid, aspartic acid, arginine, glycine, alanine, tyrosine, and cysteine) compared with other major cereals that are common in human consumption, such as rice, corn, and wheat. In Table 1, these results show that quinoa seeds have a high content of Glutamic acid (20.07%), followed by Glycine (15.33%) and Aspartic acid (8.28%) as non-essential amino acids. Also, it has a high content of Cystine, Lysine, Leucine, and Methionine (9.27,5.78,4.35,4.29, respectively). while quinoa seeds had the lowest content of Phenylalanine and Tryptophan (1.02 and 1.12)

Name of fatty acids	Quinoa seeds%
Myristic (C14:0)	0.35
Palmitic (C16:0)	8.41
Palmitoleic (C16:1)	0.21
Stearic (C18:0)	0.85
Oleic (C18:1)	22.1
Linoleic (C18:2)	55.00
Gamma Linolenic (γ-C18:3n6)	0.11
Linolenic (α-C18:3n3)	9.49
Arachidic (C20:0)	0.25
Gadoleic (C20:1)	0.83
Erucic (C22:1)	1.40
Σ Saturated Fatty Acids	9.86
Σ Monounsaturated fatty acids	24.54
Σ Polyunsaturated fatty acids	64.60
Oleic/linoleic ratio	0.40
Sat./unsat ratio	0.11
Predicated of the Protein Efficiency ratio(P-PER)	0.92

Table 2: Fatty acid composition of Quinoa Seeds:

Table 2 displays the results of the current study on fatty acids. The fat content revealed a diverse range of fatty acids, with linoleic acid (omega-6 polyunsaturated fatty acids) making up most of them. Quinoa seeds had the highest fatty acid content (55.00%), followed by oleic acid (22.1%) and a-linolenic acid (9.49%). On the whole, quinoa seeds have a low percentage of total saturated fatty acids (9.86%), a high percentage of polyunsaturated fatty acids (64.60%), and a low percentage of monounsaturated fatty acids (25.54%).

Lipids are essential for human health and nutrition, as they affect a range of physical processes and disease outcomes, serve as a primary energy source, and play important roles in diverse biological functions. They are crucial for the structure and function of cell membranes. In contrast, polyunsaturated fatty acids (PUFAs), including omega-3 fatty acids, have been associated with anti-inflammatory effects and a reduced risk of cardiovascular disease (Amin *et al*., 2019; Zhang *et al*.,2021).

Essential fatty acids can be grouped into two families called omega-3 (alpha-linolenic acid) and omega-6(linoleic acid), which are known to be essential to human health and are known as polyunsaturated fatty acids that make up the majority of quinoa oil in this study. In quinoa, unsaturated fatty acids account for 88% of the total fatty acids and consist primarily of oleic (19.97%–22.2%), linoleic (59.35%–71.87%), and linolenic acids (3.54%–6.21%), similar to those in soybean oil (Shen *et al*., 2022). Essential fatty acids can be found in quinoa seeds, making them a viable alternative to oilseeds (Mohamed Ahmed *et al*., 2021).

Table 2 displays the composition of unsaturated fatty acids, which are the main fatty acids obtained from whole quinoa. Quinoa whole contains Myristic, Palmitic, Palmitoleic, Stearic, Oleic, Linoleic, γ-Linolenic, α-Linolenic, Arachidonic, and Eicosenoic acids (0.35,8.41,0.21,0.85,22.10,55.00,0.11,9.49,0.25,0.83, and 1.40) g/100 g, respectively. Linoleic acid was the main fatty acid detected, followed by oleic acid, α-Linolenic, and palmitic acid. Wu *et al*. (2020) observed that quinoa has the highest linoleic acid content. This distinctive fatty acid profile benefits human health by lowering cardiovascular disease risk factors (Farinazzi-Machado *et al*., 2012).

To determine the fatty acid composition of any oil, it's important to know the ratio of total saturated fatty acid to total unsaturated fatty acid, which is associated with the oil's oxidation stability, and the oleic/linoleic ratio, which has a positive effect on the oil's taste (Ranalli *et al.*, 2001).

Based on the previous results, we recommend using quinoa seeds as a high-nutritional alternative and expanding their cultivation to compensate for the shortage of wheat.

Conflicts of Interest:

The authors declare no conflict of interest.

References

1. Abdelshafy, A. M., El-Naggar, E. A., and Kenawi, M. N. (2022). Moringa leaves for improving the health benefits of quinoa fermented by probiotics. Food Bioengineering, 1, 264–275.
2. Al-Sheraji, S.H., Ismail, A., Manap, M.Y., Mustafa, S., Yusof, R.M., and Hassan, F.A. (2013). Prebiotics as functional foods: a review. J. Funct. Foods 5, 1542–1553.
3. Angeli, V., Miguel Silva, P., Crispim Massuela, D., Khan, M.W., Hamar, A., Khajehei, F., Graeff-Hönninger, S., Piatti, C. (2020) Quinoa (Chenopodium quinoa Willd): An overview of the potentials of the “golden grain” and socio-economic and environmental aspects of its cultivation and marketization. Foods, 9, 216.
4. Annunziata MG, Attico A, Woodrow P, Oliva MA, Fuggi A, Carillo P. (2012). An improved fluorimetric HPLC method for quantifying tocopherols in Brassica rapa L. subsp. sylvestris after harvest. Journal of Food Composition and Analysis. 1;27(2):145-50.
5. AOAC. Association of Official Analytical Chemists. Official Method of Analysis. 2007. (18th Ed.), chapter 33, pp. 10, 70-72, chapter 45, pp. 101, Benjamin Franklin Station Washington, D.C., USA.
6. Barbé, F., Le Feunteun, S., Rémond, D., Ménard, O., Jardin, J., Henry, G., Dupont, D. (2014). Tracking the in vivo release of bioactive peptides in the gut during digestion: Mass spectrometry peptidomic characterization of effluents collected in the gut of dairy matrix. Food Research International, 63, 147–156.
7. Betoret, E., Betoret, N., Vidal, D., and Fito, P. (2011). Functional foods development: Trends and technologies. Trends Food Science Technology, 22, 498–508.
8. Bolanos, ˜ D., Marchevsky, E.J., Camina, ˜ J.M. (2016). Elemental analysis of amaranth, Chia, sesame, linen, and quinoa seeds by ICP-OES: assessment of classification by chemometrics. Food Anal. Methods 9, 477–484.
9. Cassman, K. G., and Liska, A. J. (2007). Food and fuel for all: realistic or foolish? Bio- fuels, Bioproducts and Biorefining, 1, 18e23.
10. Chen, Q.-F., Huang, X.-Y., Li, H.-Y., Yang, L.-J., and Cui, Y. S. (2018). Recent progress in perennial buckwheat development. Sustainability, 10, 536.
11. Cooper, R. (2015). Re-discovering ancient wheat varieties as functional foods. J Tradit Complement Med 5: 138-143.
12. Dev, R., and Gupta, M. (2024). Elucidating the physical, chemical, functional and antioxidant properties of protein-rich quinoa (Chenopodium quinoa) crisp. Food and Humanity,2.
13. FAO (Food and Agriculture Organization of the United Nations). (2011). Cereal supply and demand brief. In FAO cereal supply and demand situation. (July 2011)
14. FAO, (2014). Assessment of the international year of quinoa 2013. In: Hundred and Forty Ninth Session - CL 149/10. FAO, Rome.
15. Farinazzi-Machado, F. M. V., Barbalho, S. M., Oshiiwa, M., Goulart, R., and Pessan Junior, O. (2012). Use of cereal bars with quinoa (Chenopodium quinoa W.) to reduce risk factors related to cardiovascular diseases. Food Science Technology, 32(2), 239–244.
16. González-Martín, M.I., Wells-Moncada, G., Fischer, S., and Escuredo, O. (2014). Chemical characteristics and mineral composition of quinoa by nearinfrared spectroscopy. J Sci Food Agric 94: 876-881.
17. Gordillo-Bastidas, E., Díaz-Rizzolo, D.A., Roura, E., Massan´es, T., and Gomis, R. (2016). Quinoa (Chenopodium quinoa Willd), from nutritional value to potential health benefits: an integrative review. J. Nutr. Food Sci. 6 (3), 497.
18. Hasan MN, Akhtaruzzaman M, Sultan MZ. (2013). Estimation of vitamins B-complex (B2, B3, B5 and B6) of some leafy vegetables indigenous to Bangladesh by HPLC method. Journal of Analytical Sciences, Methods and Instrumentation. 23;3(03):24.
19. Hussain, M. I., Farooq, M., Syed, Q. A., Ishaq, A., Al-Ghamdi, A. A., and Hatamleh, A. A. (2021). Botany, nutritional value, phytochemical composition and biological activities of quinoa. Plants, 10, 2258.
20. Jaikishun, S., Li, W., Yang, Z., & Song, S. (2019). Quinoa: In perspective of global challenges. Agronomy, 9(4), 176.
21. Kim, K.H., Tsao, R., Yang, R., Cui, S.W. (2006). Phenolic acid profiles and antioxidant activities of wheat bran extracts and the effect of hydrolysis conditions. Food Chem. 95 (3), 466–473.
22. Konishi, Y., Hirano, S., Tsuboi, H., and Wada, M. (2004). Distribution of minerals in quinoa (Chenopodium quinoa Willd.) seeds. Biosci. Biotechnol. Biochem. 68 (1), 231–234.
23. Liu, M., Liu, X., Luo, J., Bai, T., Chen, H. (2021). Effect of digestion on bound phenolic content, antioxidant activity and hypoglycemic ability of insoluble dietary fibre from four Triticeae crops. J. Food Biochem., e13746
24. Maradini Filho, A.M., Pirozi, M.R., Da Silva Borges, J.T., Pinheiro Sant'Ana, H.M., Paes Chaves, J.B., and Dos Reis Coimbra, J.S. (2015). Quinoa: nutritional, functional and antinutritional aspects. Crit. Rev. Food Sci. Nutr.

25. Miranda, M., Vega-Galvez, A., Quispe-Fuentes, I., Jose Rodriguez, M., Maureira, H., and Martinez, E. A. (2012). Nutritional aspects of six quinoa (Chenopodium quinoa willd.) ecotypes from three geographical areas of CHILE. Chilean Journal of Agricultural Research, 72, 175–181.
26. Mohamed Ahmed, I. A., Al Juhaimi, F., and Özcan, M. M. (2021). Insights into the nutritional value and bioactive properties of quinoa (Chenopodium quinoa): Past, present and future prospective. International Journal of Food Science & Technology, 56, 3726–3741.
27. Navruz-Varli, S., and Sanlier, N. (2016). Nutritional and health benefits of quinoa (Chenopodium quinoa Willd.). Journal of Cereal Science, 69, 371–376.
28. Nowak, V., Du, J., and Charrondière, U. R. (2016). Assessment of the nutritional composition of quinoa (Chenopodium quinoa Willd). Food Chemistry, 193, 47–54.
29. Pathan, S., and Siddiqui, R.A. (2022). Nutritional composition and bioactive components in quinoa (Chenopodium quinoa Willd.) greens: a review. Nutrients 14 (3), 558.
30. Pedrali, D., Giupponi, L., De la Pena-Armada, ˜ R., Villanueva-Suarez, ´ M. J., and MateosAparicio, I. (2023). The quinoa variety influences the nutritional and antioxidant profile rather than the geographic factors. Food Chemistry, 402, Article 133531.
31. Pimentel, D., Marklein, A., Toth, M. A., Karpoff, M. N., Paul, G. S., McCormack, R., Kyriazis, J., and Krueger, T. (2009). Food versus biofuels: environmental and economic costs. Human Ecology, 37, 1e12.
32. Ranalli, A., S. Contento, C. Schiavone, and N. Simone. (2001). Malaxing temperature affects volatile and phenol composition as well as other analytical features of virgin olive oil. European of lipid Sci. and Techn. 130: 228 – 238.
33. Repo-Carrasco-Valencia, R., Hellstrom, J.K., Pihlava, J.M., and Mattila, P.H. (2010). Flavo- noids and other phenolic compounds in Andean indigenous grains: quinoa (Chenopodium quinoa), kaniwa (Chenopodium pallidicaule) and kiwicha (Amaranthus caudatus). Food Chem. 120 (1), 128-133.
34. Repo-Carrasco-Valencia, R.A., C.R. Encina, M.J. Binaghi, C.B. Greco and P.A. Ronayne De Ferrer. (2010b). Effects of roasting and boiling of quinoa, kiwicha and kaniwa on composition and availability of minerals in vitro. J. Sci. Food Agric. 90:2068-73.
35. Šamec, D., Urlić, B., and Salopek-Sondi, B. (2019). Kale (Brassica oleracea var. acephala) as a superfood: review of the scientific evidence behind the statement. Crit. Rev. Food Sci. Nutr. 59, 2411–2422.
36. Shen, Y., Zheng, L., Peng, Y., Zhu, X., Liu, F., Yang, X., and Li, H. (2022). Physicochemical, antioxidant and anticancer characteristics of seed oil from three Chenopodium quinoa genotypes. Molecules, 27, 2453.
37. Siegel, D., and Babuscio, T. (2011). Mycotoxin management in the European cereal trading sector. Food Control, 22, 1145e1153.
38. Singh, D. (2019). Quinoa (Chenopodium Quinoa Willd). Scientific Publishers.
39. Sohaimy, S., Mohamed, S., Shehata, M., Mehany, T., Zaitoun, M. (2018). Compositional analysis and functional characteristics of quinoa flour. Annu. Res. Rev. Biol. 22 (1), 1–11.
40. Suriano, S., Iannucci, A., Codianni, P., Fares, C., Russo, M., Pecchioni, N., Marciello, U., Savino, M. (2018). Phenolic acids profile, nutritional and phytochemical compounds, antioxidant properties in colored barley grown in southern Italy. Food Res. Int. 113, 221–233.
41. Tang, Y., Li, X., Chen, PX., Zhang, B., Hernandez, M., Zhang, H., Marcone, M.F., Liu, R., and Tsao, R. (2015b) Characterization of fatty acid, carotenoid, tocopherol/tocotrienol compositions and antioxidant activities in seeds of three Chenopodium quinoa Willd. genotypes. Food chemistry 174: 502-508.
42. Tanwar, B., Goyal, A., Irshaan, S., Kumar, V., Sihag, M.K., Patel, A., Kaur, I. (2019). Quinoa. In Whole Grains and Their Bioactives: Composition and Health, 1st ed.; Johnson, J., Wallace, T.C., Eds.; John Wiley & Sons Ltd.: Hoboken, NJ, USA, pp. 269–305.
43. Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. Proceedings of the national academy of sciences, 108(50), 20260-20264.
44. Valeri, M., Roberto, M., Dmitriev, B. (2022). Determination of physiological maturity of four quinoa (Chenopodium quinoa Willd) varieties for introduction in the Russian Federation. Res. Crop. 23, 307–312.
45. Vega-Gálvez, A., Miranda, M., Vergara, J., Uribe, E., Puente, L., and Martínez, E. A. (2010). Nutrition facts and functional potential of quinoa (Chenopodium quinoa Willd.), an ancient andean grain: A review. Journal of the Science of Food and Agriculture,90(15), 2541–2547.
46. Vieira da Silva, B., Barreira, J.C.M., and Oliveira, M.B.P.P. (2016). Natural phytochemicals and probiotics as bioactive ingredients for functional foods: extraction, biochemistry and protected-delivery technologies. Trends Food Sci. Technol.50,144–158.
47. Wu, L., Wang, A., Shen, R., and Qu, L. (2020). Effect of processing on the contents of amino acids and fatty acids, and glucose release from the starch of quinoa. Food Science & Nutrition, 8(9), 4877–4887.
48. Xu, H. Y., Feng, X. H., Zhang, J. Y., and Ma, C. M. (2020). Recent progress in research on Agriophyllum squarrosum (L.) Moq. Food and Fermentation Industries, 41, 346–354.
49. Z˘ilic´, S., Serpen, A., Akıllıog˘lu, G., Jankovic´, M., Gökmen, V. (2012). Distributions of phenolic compounds, yellow pigments and oxidative enzymes in wheat grains and their relation to antioxidant capacity of bran and debranned flour. J. Cereal Sci. 56 (3), 652–658.
50. Zannini, E., Jeske, S., Lynch, K. M., and Arendt, E. K. (2018). Development of novel quinoabased yogurt fermented with dextran producer Weissella cibaria MG1. International Journal of Food Microbiology, 268, 19–26.
51. Zhao, P., Li, X., Sun, H., Zhao, X., Wang, X., Ran, R., Zhao, J., Wei, Y., Liu, X., and Chen, G. (2021). Healthy values and de novo domestication of sand rice (Agriophyllum squarrosum), a comparative view against Chenopodium quinoa. Critical Reviews in Food Science and Nutrition, 1–22, 4188–4209.
52. Martínez-Villaluenga, C., Peñas, E., & Hernández-Ledesma, B. (2020). Pseudocereal grains: Nutritional value, health benefits and current applications for the development of gluten-free foods. Food and chemical toxicology, 137, 111178.
53. Zhang, Y.; Zhang, T.; Liang, Y.; Jiang, L.; Sui, X. (2021). Dietary Bioactive Lipids: A Review on Absorption, Metabolism, and Health Properties. J. Agric. Food Chem., 69, 8929–8943.
54. Amin, K.A.; Homeida, A.M.; El Mazoudy, R.H.; Hashim, K.S.; Garelnabi, M. (2019). Dietary Lipids in Health and Disease. J. Lipids, 2019, 5729498

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