Nutritional and biochemical characterization of lentil, chickpea, and quinoa

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Abstract

In this study, a random sample of chickpeas, lentils, and quinoa was characterized physically, chemically, and nutritionally. The results showed that lentils had a higher level of protein (21%), while chickpeas had higher moisture content (16.1%). Lentils and quinoa contained the same amount of fiber (14%). Mineral content was evaluated in all samples, with quinoa showing the highest amounts of copper (79.63 mg/kg), zinc (24.3 mg/kg), phosphorus (4064 mg/kg), and magnesium (3625 mg/kg). Chickpeas, on the other hand, had higher amounts of sodium (2133 mg/100g) and calcium (1304 mg/100g). Chickpeas also contained higher amounts of ascorbic acid (67 mg/100g), thiamine (1.83 mg/100g), riboflavin (2.03 mg/100g), niacin (23.3 mg/100g), and α-tocopherol (29 mg/100g) compared to quinoa and lentils. Lentils had a higher amount of folate (477.5 µg/100g). Chickpeas also contained higher levels of leucine (7.13 g/100g) and phenylalanine (5.7 g/100g). The total amino acid content in lentils was 37.89 g/100g, with the highest amounts of leucine (7.2 g/100g) and lysine (7.26 g/100g). Quinoa contained the richest amount of leucine (7.03 g/100g), and the total amino acid content in quinoa was 34.93 g/100g. In conclusion, all the samples showed different nutrient values across the grains. Quinoa exhibited higher values in bioactive compounds. Due to their higher nutritional content, these grains are recommended for daily intake.

Keywords: antioxidants, cereals, chickpeas, lentils, protein, pulses, quinoa

Introduction

Silva *et al.* (2009) explained that cereal bars were first developed approximately ten years ago and offer a replacement food that is both functional and easy to ingest. A pulse known as chickpea (Cicer arietinum L.) is very popular and consumed globally. According to Grasso *et al.* (2022), like all other cereals and carbohydrates, chickpeas are a beneficial source of fats, protein, and fiber . Shevkani *et al.* (2019) evaluated that chickpeas contain minerals, carbohydrates, lipids, and bioactive substances. In addition to protein, chickpea protein components contain antinutrients, all of which influence the productivity of recovery and critical quality characteristics. Chickpea seeds, and pulses in general, have different nutritional profiles depending on soil

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nourishment, biology, environment, agronomic techniques, and stress factors, all of which are important to consider. According to Kaur and Parasad (2021), the main component of the carbohydrate fraction is starch (47.4%–66.9%), which accounts for 41.0%–50.8% of the total carbohydrate content in chickpeas, along with crude fiber, digestible sugars, and dietary fiber, which account for the remaining portion of the carbohydrate content. Summo *et al*. (2019) found that minerals and vitamins are other significant components of chickpeas. Chickpeas contain more nutrients, such as vitamins C, A, E, and K, as well as B-complex vitamins, zinc, and phosphorus, compared to other legumes. Chickpeas also include phenolic compounds (such as formononetin and isoflavones like biochanin A) and carotenoids, which are found in larger amounts in brown and black chickpea cultivars. Brummer *et al*. (2015) verified this. Lentil (Lens culinaris) is a high-fiber, low-fat leguminous plant. The amount of total soluble fiber is lower in peas and chickpeas than in lentils. Lentils also have a higher nutritional fiber content than beans and chickpeas. Just like most other legumes, lentils have a high protein content, ranging from 20.6% to 31.4%. Lentil proteins are made up of roughly 16% albumins, 11% glutelins, 70% globulins, and 3% prolamins. The lentil crop is generally grown in areas without adequate irrigation, depending on the water contained in the soil after heavy rains in the fall and winter. Lentil crops help fix nitrogen from the air into the soil, reducing the need for nitrogen fertilizers and the soil's inorganic nitrogen levels. When combined with sulfur-containing amino acids found in wheat, rice, or other cereal grains, lentil protein meets daily critical amino acid requirements without the use of animal proteins. It's a low-cost source of plant protein that can be used to feed people in impoverished countries. To increase the usage of lentil proteins in foods, supplements, and functional food formulas, two important challenges must be addressed: processing costs and intrinsic tastes. Quinoa's protein composition ranges from 13.8% to 16.5%, with an average of 15%. Quinoa's (Chenopodium quinoa Wild.) oil content ranges from 2% to 9.5%, and it is high in essential fatty acids like linoleic and linolenic acid, as well as natural antioxidants like α- and γ-tocopherol. Kaur *et al*. (2018) established a gluten-free cereal bar made from quinoa with 10.50% protein content, according to the manufacturer. The bar's crude protein content was 14.43%. Leucine (892.10 mg/100g), isoleucine (688.80 mg/100g), lysine (561.01 mg/100g), and valine (530.40 mg/100g) were all present in high concentrations in the Choco Quinoa Nutri Bar. The threonine concentration was 388.90 mg/100g, with other essential amino acids ranging from 110 to 181 mg/100g. Among the non-essential amino acids detected in the bar, L-Aspartic acid was found in the highest concentration (596.26 mg/100g), followed by L-Proline (308.40 mg/100g) and L-Alanine (301.50 mg/100g). L-Cysteine was detected in the bar in a very small proportion, 30.01 mg/100g (Garg and Brar, 2017). The primary reason for conducting this study is that chickpeas, lentils, and quinoa are rich in nutritional compounds. Chickpeas and quinoa are not commonly used in our daily lives. The purpose of this study is to examine their nutritional and bioactive constituents to explain their health-promoting perspectives. Free radicals cause oxidative stress, high levels of free radical species are known to cause pathological conditions (Akpinar *et al.*, 2023; Al-Saeed *et al.*, 2023; Rakha *et al.*, 2023; Khan *et al.*, 2024; Yiğit *et al.*, 2024; Al-Gheffari *et al.*, 2024; Amrozi *et al.*, 2024; Balgoon *et al.*, 2024; Elzaiat *et al.*, 2024; Rashid *et al.*, 2024; Saadullah *et al.*, 2024). Quinoa, lentils, and chickpeas are high in protein, flavonoids, polyphenols, and tocopherols which exhibit strong antioxidant potential. Quinoa and quinoa products are rich in micronutrients, including polyphenols, vitamins, and minerals, as well as macronutrients like protein, polysaccharides, and lipids. All of these food bars play a vital role in our society because they help prevent diseases and promote good health.

Material and Methods

Chemical analysis

For chemical analysis, the chemical composition of chickpea, lentil, and quinoa samples was analyzed, including moisture content, ash content, crude fat, crude protein, and crude fiber, which were quantified according to their relevant procedures.

Moisture content

Using an oven with a forced draught (Memmet, Germany) set to a temperature of 105±5°C, samples were collected from chickpea, lentil, and quinoa and analyzed for their moisture content, according to method No. 44-I5A AOAC 2000.

Protein content

As designated in method No. 46-30 2000, samples of chickpea, lentil, and quinoa were taken, and their protein content was analyzed using Kjeldahl's method.

Fat content

The fat content percentage was observed, and samples were taken for the determination of fat content. The Soxhlet apparatus was used for the determination, according to method No. 30-25, AOAC 2000.

Fibre content

For the analysis of crude fiber, samples of chickpea, lentil, and quinoa were taken, following the instructions outlined in Method No. 32-10, AOAC 2000.

Ash content

A muffle furnace, set to a temperature of 550°C, was used to evaluate the ash content of chickpea, lentil, and quinoa samples by burning them. After burning, a desiccator was used to cool the remaining sample, which was then weighed. The ash content was determined by calculating the variance between the sample's initial weight and the weight after burning in the muffle furnace. The calculated ash content is expressed as a percentage, according to method No. 08-01, AOAC 2000.

Mineral content

According to method AACC, 2000, iron, sodium, copper, zinc, magnesium, potassium, and calcium are typically determined using two methods: flame photometry and atomic absorption spectrophotometry.

Vitamin content

Vitamins were calorimetrically determined using the method of Lebiedzinska *et al*. (2007), where thiamine is quantified and separated by the HPLC technique. Riboflavin, niacin, and vitamin B-12 were also determined using a chromatographic method (reverse-phase).

Amino acids

A high-speed amino acid analyzer (LA8080 amino SAAYA, High Tec Solution, Japan) was used to determine the amino acids in chickpeas, lentils, and quinoa, according to the technique presented by Biel *et al*. (2009). After the amino acids were isolated using the cation exchange column, the ninhydrin method was applied to evaluate the amino acids with a UV/VIS spectrophotometer.

Bioactive compounds

Phenolic content

Miliauskas *et al*. (2003) described the Folin-Ciocalteu method for determining the total phenolic levels in chickpeas, lentils, and quinoa.

Flavonoids

The total flavonoid content (TFC) of chickpeas, lentils, and quinoa was analyzed using the method of Nongalleima *et al*. (2017).

Quercetin and Kaempferol

Dmitrienko *et al*. (2012) explained that spectroscopic, chromatographic, and electrophoretic methods are the most common techniques for determining quercetin. Spectrophotometry and luminescence are commonly used to analyze quercetin samples with a relatively simple formulation, particularly dietary supplements and pharmaceutical treatments. In contrast, GC–mass spectrometry, HPLC, and capillary electrophoresis are employed to determine this compound in natural sources and biological fluids. Recently, new electrochemical approaches for identifying quercetin have gained popularity.

Phytosterols

Lagarda *et al*. (2006) explained that HPLC has been the method of choice for the examination of sterols and related substances. As a result, it appears to be ideal for investigating thermally unstable substances like sterols.

Results and Discussions

Moisture content

The moisture content of chickpeas, lentils, and quinoa was analyzed through physicochemical characterization. The data showed that the mean moisture content of chickpeas was 16.1%, lentils was 17%, and quinoa was 8.75%. The moisture content of lentils was higher than that of the other samples.

The results indicated that the moisture content of chickpeas was 16.1%, which was quite similar to the research conducted by Eissa AH *et al*. (2010), who found that moisture content ranged from 11.6% to 25.4%. Another researcher, Chelladurai *et al*. (2020), reported that the moisture content of lentils was 16%, consistent with the results of our study. Jan *et al*. (2019) investigated the moisture content of quinoa and found it to be 10%. To determine how fermentation affects the structure, quality, digestibility, and non-nutritive components of lentil proteins (Lens culinaris), red in digestibility, secondary protein structural components, sugars, and phenolic compounds were examined. Water kefir seeds were used for the fermentation process. At the end of the fermentation on day 5, the original pH of the unfermented lentil proteins dropped from 6.8 to pH 3.4. Over the 5 days of fermentation, protein digestibility improved from 76.4% to 84.1%. After two days of fermentation, the total phenolic content increased from 443.4 to 792.6 mg GAE/100g, with the sum of detected phenolic

compounds from HPLC analysis reaching about 500 mg/100g, as reported by Alrosan *et al*. (2021). Therefore, all the results from previous investigations are in accordance with our study.

Protein

The protein content was evaluated, and the mean ratios of all three samples were analyzed carefully. The mean protein content in chickpeas, lentils, and quinoa was 20%, 21%, and 12.9%, respectively. Therefore, the protein content was higher in lentils compared to quinoa and chickpeas.

The mean results align with some previous findings. Boukid *et al*. (2021) investigated protein content and found it to be between 17% and 22%, which is comparable to our findings. Another researcher, Lake *et al*. (2021), reported that the protein content of lentils was 22%. A study by Bawachkar *et al*. (2021) reported a protein content of 14.43%, which is similar to the findings of this research.

Fat

Rachwa-Rosiak *et al*. (2015) explained that triglycerides make up the majority of neutral lipids, while lecithin makes up the majority of polar lipids. Chickpea grains contain a significant amount of important unsaturated fatty acids in their fat. Lentils, on the other hand, have a relatively low fat content. Fat content was analyzed through physicochemical characterization. The mean values for fat content in chickpeas, lentils, and quinoa were 7.7%, 1.2%, and 4.06%, respectively. The fat content in chickpeas is higher than in the other samples, while lentils have a lower fat content. A study by Ando *et al*. (2002) reported a fat content of 6.5% in quinoa, which is comparable to the fat content found in chickpeas in our study. Other researchers, Madurapperumage *et al*. (2021), found that the fat content in chickpeas ranged from 3.8% to 10.2%. Faris *et al*. (2013) reported that the fat content in lentils was 1.1%, which aligns with the findings of the current study.

Fiber

The mean values of the results indicated that the crude fiber content in the chickpea sample was 12.36%, in lentils was 14%, and in quinoa was 14.1%. The fiber content in lentils and quinoa was higher compared to chickpeas. Overall, the results showed that all three samples have a rich amount of fiber. Singh *et al*. (2016) suggested that the fiber content in lentils was 15%, which is comparable to our results. An investigation by Wallace *et al*. (2016) reported the fiber content in chickpeas as 12%, and the fiber content in quinoa was 13.9%.

Ash

The results analyzed the ash content of all three samples. The mean ash content in chickpeas, lentils, and quinoa was 3.57%, 3.14%, and 3.13%, respectively. Ando *et al*. (2002) evaluated the ash content in quinoa as 3.0%. Researchers, including Ramdath *et al*. (2020), observed the ash content in lentils to be 3.13%. Another study conducted on chickpeas showed the ash content to be 3.54%, as reported by Khattak *et al*. (2021), as shown in Table 1.

Mineral

Quinoa is higher in quality protein and contains more nutrients than most other cereals. It is rich in several minerals, including manganese, phosphorus, copper, folate, iron, magnesium, and zinc, among others. Lentils are high in fiber and minerals, making them a healthy choice for managing heart health, blood pressure, and cholesterol levels. The calcium, magnesium, fiber, and other nutrients found in chickpeas and other legumes contribute to strong bones.

Table 2 shows the results of the different mineral content in the quinoa, lentils, and chickpeas samples. The mean values of mineral content evaluated in quinoa were 880 mg/kg for Ca, 98.4 mg/kg for Fe, 3625 mg/kg for Mg, 4064 mg/kg for P, 201 mg/kg for Na, 24.3 mg/kg for Zn, and 79.63 mg/kg for Cu. The mean mineral content in chickpeas was 1304 mg/100g for Ca, 4.61 mg/100g for Fe, 403 mg/100g for Mg, 253 mg/100g for P, 2133 mg/100g for Na, 16 mg/100g for Zn, and 3.33 mg/100g for Cu. The mean mineral content of lentils was evaluated as 58

Table 1. Proximate composition of chickpeas, lentils, and quinoa.

Proximate Testing	Chickpeas %	Lentils %	Quinoa %
Moisture	16.1 ± 6.5^{A}	17 ± 0.81^{A}	8.75 ± 3.07^{B}
Protein	20 ± 2.6^{A}	21 ± 1.05^{A}	12.9 ± 1.0^{B}
Fat	7.7 ± 1.6^{A}	1.2 ± 1.7^{C}	4.6 ± 0.1^{B}
Ash	3.57 ± 0.03^{A}	3.14 ± 0.01^{AB}	3.13 ± 0.23^{B}
Crude fiber	12.3 ± 0.15^{B}	14.0 ± 1.12^{A}	14.1 ± 0.30^{A}
NFE	40.33^{B}	43.66^{B}	56.7^{A}

Values are mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other ($p \leq 0.05$).

Table 2. Mineral composition of chickpeas, lentils, and quinoa (mg /100g ash a sample; on dry weight basis).

Minerals	Chickpeas mg/100g	Lentils mg/100g	Quinoa mg/kg
Calcium	1304 ± 0.67^{A}	58 ± 0.45^{C}	880 ± 3.21^{B}
Iron	4.61 ± 2.12^{C}	7.8 ± 1.15^{B}	98.4 ± 4.1^{A}
Magnesium	403 ± 5.0^{B}	125 ± 4.3^{C}	3625 ± 4.0^{A}
Phosphorous	253 ± 4.04^{C}	457 ± 4.58^{B}	4064 ± 7.02^{A}
Sodium	2133 ± 2.34^{A}	8.12 ± 2.2^{C}	201 ± 3.6^{B}
Zinc	16 ± 1.12^{B}	5.3 ± 0.45^{C}	24.3 ± 3.5^{A}
Copper	3.33 ± 1.5^{B}	1.16 ± 0.70^{C}	79.63 ± 1.12^{A}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other ($p \leq 0.05$).

mg/100g for Ca, 7.8 mg/100g for Fe, 125 mg/100g for Mg, 457 mg/100g for P, 8 mg/100g for Na, 5.3 mg/100g for Zn, and 1.16 mg/100g for Cu.

Similar outcomes have been reported by various studies. Nowak *et al*. (2015) conducted a study with results similar to those found for quinoa. Additionally, Wallace *et al*. (2016) had comparable outcomes for chickpeas. Faris *et al*. (2013) conducted a study in which the results for lentils were in accordance with our findings.

Vitamins

Vitamins are water-soluble compounds that are essential for human and animal health. They are categorized into two classes based on their solubility: lipophilic (fat-soluble) and hydrophilic (water-soluble). Vitamins have traditionally been among the most extensively used chemical agents to enhance the nutritional value of food products. Chickpeas contain a moderate amount of calories along with several vitamins and minerals. Vitamin E is a crucial component of quinoa because, at the cell membrane level, it acts as an antioxidant, preventing free radical damage to the fatty acids in cell membranes (Repo-Carrasco *et al*., 2003). Table 3 shows the main vitamins found in quinoa, chickpeas, and lentils. Higher amounts of ascorbic acid (67 mg/100g), thiamine (1.83 mg/100g), riboflavin (2.03 mg/100g), niacin (23.3 mg/100g), and α-tocopherol (29 mg/100g) are present in chickpeas compared to quinoa and lentils. Lentils are particularly high in folate (477.5 µg/100g).

Vega-Gálvez *et al*. (2010) evaluated the vitamin content in quinoa, which aligns with our results. They reported the following vitamin contents in quinoa: ascorbic acid (C) 4.0 mg/100g, α-tocopherol (E) 5.37 mg/100g, thiamine (B1) 0.38 mg/100g, riboflavin (B2) 0.39 mg/100g, and niacin (B3) 1.06 mg/100g. Wallace *et al*. (2016) observed the vitamin content in chickpeas, with the following results: ascorbic acid (C) 60 mg/100g, α-tocopherol (E) 30 mg/100g, thiamine (B1) 1.5 mg/100g, riboflavin (B2) 1.7 mg/100g, niacin (B3) 20 mg/100g, and folate 400 µg/100g. Takruri *et al*. (2013) also concluded similar results for lentils.

Amino acids

Lentils, chickpeas, and quinoa are significant sources of essential amino acids. Like most other plant-based protein sources, chickpeas do not provide a complete protein, as they lack all nine essential amino acids. Chickpeas are particularly high in arginine and lysine but low in methionine and cysteine, which are sulfur-containing amino acids. Lentils contain essential amino acids such as isoleucine and lysine, but are generally low in methionine and cysteine. Despite being a small seed, quinoa is rich in protein. Unlike some other plant proteins, quinoa is considered a complete protein, meaning it contains all nine essential amino acids that the human body cannot produce on its own.

Table 4 shows the results of all amino acids in the three grains. The total amount of amino acids in chickpeas is 38.6g/100g. The mean values are presented,

Table 3. Vitamin E and B-complex of chickpeas, lentils, and quinoa (mg /100g).

Vitamins	Chickpeas mg/100g	Lentils mg/100g	Quinoa mg/100g
Ascorbic Acid (Vitamin C)	67 ± 2.82^{A}	4.6 ± 0.70^{C}	8.5 ± 2.12^{B}
Thiamine (B1)	1.83 ± 0.30^{A}	1.5 ± 0.36^{A}	0.38 ± 0.04^{B}
Riboflavin (B2)	2.03 ± 0.41^{A}	0.36 ± 0.37^{B}	0.41 ± 0.03^{B}
Niacin (B3)	23.3 ± 3.51^{A}	2.2 ± 2.51^{B}	1.05 ± 0.03^{C}
Folate	405.5 µg/100g ± 6.36^{AB}	477.5 µg/100g± 9.19^{A}	395.5 µg/100g ± 7.77^{B}
α-tocopherol (Vit E)	29 ± 3.6^{A}	0.53 ± 0.35^{C}	5.42 ± 0.05^{B}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other ($p \leq 0.05$).

Table 4. Amino acid content of chickpeas, lentils, and quinoa (mg /100g).

Amino acids	Chickpeas g/100g	Lentils g/100g	Quinoa g/100g
Phenylalanine	5.7 ± 0.26^{A}	4.5 ± 0.40^{B}	4.2 ± 0.288^{B}
Leucine	7.1 ± 0.65	7.2 ± 0.65	7.03 ± 0.68
Isoleucine	4.6 ± 0.30^{A}	4.4 ± 0.41^{AB}	3.9 ± 0.90^{B}
Lysine	6.4 ± 0.30^{B}	7.2 ± 0.25^{A}	4.3 ± 0.55^{C}
Methionine	1.3 ± 0.20^{B}	0.39 ± 0.44^{C}	1.6 ± 0.2^{A}
Valine	4.23 ± 0.25^{C}	5.3 ± 0.32^{A}	4.40 ± 0.40^{B}
Tyrosine	2.8 ± 0.30^{B}	3.10 ± 0.26^{A}	2.20 ± 0.35^{B}
Histidine	3.1 ± 0.31^{A}	2.8 ± 0.55^{B}	2.9 ± 0.20^{B}
Threonine	3.2 ± 0.41^{AB}	3.1 ± 0.45^{B}	3.8 ± 0.30^{A}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other (p ≤ 0. 05).

Table 5. Phenolic acids in chickpeas, lentils, and quinoa (µg/100g).

Phenolic acids	Chickpeas µg/100g	Lentils µg/100g	Quinoa µg/100g
Ferulic acid	8.52 ± 0.40^{C}	12.48 ± 0.03^{B}	15.36 ± 0.15^{A}
p-Coumaric acid	2.5 ± 0.4^{C}	13.7 ± 0.19^{A}	6.45 ± 0.05^{B}
p-OH-benzoic acid	4.86 ± 0.20^{A}	1.55 ± 0.05^{C}	3.73 ± 0.19^{B}
Vanillic acid	0.48 ± 0.03^{C}	6.17 ± 0.01^{B}	8.95 ± 0.03^{A}
Protocatechuic	1.8 ± 0.025^{B}	5.89 ± 0.061^{A}	1.92 ± 0.03^{B}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other (p ≤ 0. 05).

with chickpeas having the highest amounts of leucine (7.13g/100g) and phenylalanine (5.7g/100g). The total amino acid content in lentils is 37.89g/100g, with the highest amounts of leucine (7.2g/100g) and lysine (7.26g/100g). Quinoa contains the richest amount of amino acid leucine (7.03g/100g), and the total amino acids in quinoa amount to 34.93g/100g.

Miranda *et al*. (2012) reported similar findings regarding the amino acids in quinoa grains, with the highest quantity of leucine being 6.8g/100g. Samaranayaka *et al*. (2017) also found results that align with our study. The findings for chickpeas and lentils in the current study are consistent with previous research.

Phenolic content

Ganesan *et al*. (2017) explained that lentils have the highest total phenolic concentration. Lentils, rich in polyphenols, offer potential health benefits as alternative and complementary treatments, including antioxidant, antiviral, cardioprotective, antibacterial, nephroprotective, antifungal, anti-inflammatory, and antidiabetic properties. Chickpeas were also investigated for their phenolic profiles, though they contain fewer phenolic acids compared to other grains. Quinoa, on the other hand, had the highest concentration of bound phenolics. A higher phenolic content in quinoa was associated with stronger antioxidant properties, as well as the inhibition of pancreatic lipase and beta-glucosidase activities.

The mean values of all phenolic acids are presented in Table 5. The highest concentration of phenolic acids is found in quinoa grains, while the lowest is found in chickpeas, as shown in the table. Liu *et al*. (2020) reported similar results for lentils in line with our study. Similar findings for quinoa were observed in a study by Repo-Carrasco-Valencia *et al*. (2010). Quintero-Soto *et al*. (2018) also reported similar results for chickpeas.

Bioactive compounds

Antioxidants and phenolic compounds are helpful in improving human health (Abd-El Ghany *et al.*, 2023; Tahir *et al.*, 2024; Rueangsri *et al.*, 2025). These antioxidants have a positive effect on nutrient digestibility (Hegazy *et al.,* 2023). Wang *et al*. (2021) explained that chickpeas contain various beneficial and abundant compounds. The bioactivities of the chickpea plant have been observed in several areas of the plant. Lentil (Lens culinaris; Fabaceae) is high in polyphenol compounds that possess a variety of health-promoting characteristics. Lentils, being high in polyphenols, may have a positive effect on human well-being. Polyphenols, which include flavonoids, phenolic acids, and tannins, are secondary plant metabolites with bioactive properties that contribute to a wide range of physiological benefits, including anti-carcinogenic, antimicrobial, anti-inflammatory, antioxidant, and antitumor effects, according to Benavente-Garca *et al.* (2008).

Total phenolic content

Phenolic compounds have antioxidant effect (Ramaiyulis *et al.*, 2023). The total phenolic content of chickpeas was 124.33 mg/100g, lentils 28 mg/100g, and quinoa 54.66 mg/100g. The highest phenolic content is present in chickpeas among all. The mean result for the total phenolic content (TPC) of chickpeas was 124.33 mg/100g. León-López *et al*. (2020) obtained similar results in their study, evaluating the total phenolic content at 128.3 mg/100g. Kalogeropoulos *et al*. (2010) discussed

Table 6. Bioactive components of chickpeas, lentils, and quinoa.

Bioactive contents	Flavonoids mg/100g	TPC mg/100g	Quercetin mg/100g	Kaempferol mg/100g
Chickpeas	27.36 ± 1.66^{C}	124.33 ± 3.53^{A}	0.89 ± 2.753^{D}	48.9 ± 1.67^{B}
Lentils	151.66 ± 2.14^{A}	28 ± 1.15^{C}	1.77 ± 0.049^{D}	50.5 ± 2.23^{B}
Quinoa	126.66 ± 3.51^{A}	54.66 ± 2.41^{B}	19.83 ± 0.045^{D}	43.23 ± 3.34^{C}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other ($p \leq 0.05$).

Table 7. Phytosterol components of chickpeas, lentils, and quinoa.

Phytosterols	Chickpeas mg/100g	Lentils mg/100g	Quinoa mg/100g
Phytosterol	204.6 ± 3.51^{A}	154.0 ± 4.58^{B}	116.3 ± 3.78^{C}
β-sitosterol	154.2 ± 4.81^{A}	126.8 ± 2.98^{B}	66.9 ± 2.81^{C}
Campesterol	19.46 ± 2.24^{A}	16.66 ± 1.52^{B}	17.53 ± 1.74^{AB}
Stigmasterol	21.3 ± 2.2^{A}	18.26 ± 2.1^{B}	4.50 ± 1.2^{C}
Δ5-avenasterol	3.46 ± 0.13^{A}	2.28 ± 0.064^{AB}	2.16 ± 0.04^{B}

Values are presented as mean ± SD. Values within the same column for each parameter that have different letters are significantly different from each other ($p \leq 0.05$).

the total phenolic content of lentils in their research and found similar results, with a content of 26 mg/100g. On the other hand, a study by Repo-Carrasco-Valencia *et al.* (2010) investigated the total phenolic content in quinoa, reporting values ranging from 16.8 to 59.7 mg/100g.

Total flavonoid content

Flavonoids are group of antioxidant compounds found in many different plants, and they have diverse biological activities (Tuyen *et al.*, 2025). Flavonoids have antioxidant, anti-inflammatory, anti-tumor, and blood clot-inhibiting properties. Each of these traits supports overall health (Anwar *et al.*, 2023). On the other hand, the results showed that the mean flavonoid content in chickpeas was 27.36 mg/100g, in lentils 151.66 mg/100g, and in quinoa 126.66 mg/100g. The highest flavonoid content was observed in lentils. Similar to the total phenolic content, total flavonoids have been studied in many researches. The mean flavonoid content in chickpeas was 27.36 mg/100g. León-López *et al.* (2020) reported similar findings, evaluating the flavonoid content in chickpeas at 27.6 mg/100g. Xu *et al.* (2011) also found a high amount of flavonoids in their research, estimating the flavonoid content in lentils at 221 mg/100g, which aligns with our study.

Quercetin content

Quercetin being a notable polyphenol exhibit strong antioxidant and antibacterial potential (Ahmad *et al.*, 2024). As shown in Table 7, the amount of quercetin was highest in quinoa at 19.83 mg/100g, followed by lentils at 1.77 mg/100g, and the lowest amount was found in chickpeas at 0.89 mg/100g. Hirose *et al.* (2010) reported the total quercetin content in quinoa as 22.5 mg/100g, which aligns with our findings. Han *et al.* (2008) evaluated the quercetin content in lentils as 1.78 mg/100g and in chickpeas as 0.84 mg/100g.

Kaempferol

Kaempferol is a flavonoid found naturally in a variety of plants and plant-derived foods. It is known to reduce the risk of chronic diseases, particularly cancer. As shown in Table 6, the kaempferol content in chickpeas was 48.9 mg/100g, in lentils was 50.5 mg/100g, and in quinoa was 43.23 mg/100g. Díaz-Batalla *et al.* (2006) investigated that the kaempferol content in lentils was 52.3 mg/100g, which aligns with our study. Another researcher, Lee *et al.* (2018), conducted a study in which he reported that the kaempferol content in quinoa was 45.12 mg/100g.

Phytosterols

Phytosterols are lipophilic molecules that resemble cholesterol in structure. According to intervention trials, epidemiological evidence, and meta-analyses, phytosterols have a significant impact on lowering cholesterol levels in individuals (Graf *et al.*, 2010). Phytosterols reduce blood cholesterol by competing with cholesterol for absorption in the intestine and inhibiting the formation of atherogenic lipoproteins in both the liver and intestines (Ho and Pal, 2005). As shown in Table 8, the phytosterol content in chickpeas (204.6 mg/100g) is higher than in the other grains. Lentils (154 mg/100g) and quinoa (116.3 mg/100g) have lower amounts of phytosterols and their constituents.

The phytosterol content in chickpeas and lentils was found to be 204.6 mg/100g and 154 mg/100g, respectively. These results were similar to those evaluated by Singh *et al*. (2017), who reported phytosterol content in chickpeas (205 mg/100g) and lentils (158 mg/100g). Navruz-Varli *et al*. (2016) suggested that quinoa contained 118 mg/100g of phytosterol content. These researchers also analyzed other phytosterol constituents. Ryan *et al*. (2007) reported that the β-sitosterol content in chickpeas and lentils was 159.8 mg/100g and 123.4 mg/100g, respectively, as shown in Table 7.

Conclusion

The findings of this scientific study indicate that all three grains—chickpeas, lentils, and quinoa—are rich in nutrients that offer significant health benefits. These grains serve as excellent substitutes for animal proteins and are also high in other valuable functional properties, such as total flavonoid and total phenolic content. Moreover, lentils, quinoa, and chickpeas can be used as food fusion ingredients and are promising options for designing functional foods, thanks to their bioactive compounds and nutraceutical potential. This type of research is currently unexplored in Pakistan, as no previous study of this magnitude has been conducted. This work represents a significant step forward for the processing sector, as it aims to isolate and extract bioactive substances with nutritional relevance that can contribute to reducing the prevalence of chronic diseases. Ultimately, this study could open the door for further research into the phytochemicals with nutraceutical value present in these grains.

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Data Availability Statement

The datasets generated used and/or analyzed during the current study available from the corresponding author on reasonable request.

Consent to Participate

All the co-authors are willing to participate in this manuscript.

Consent for Publication

All authors are willing for publication of this manuscript

Authors Contribution

Sharafat Ali Anjum: original draft, methodology equal; Muhammad Umair Arshad: supervision, draft writing and reviewing equal; Ali Imran: formal analysis and reviewing equal; Hamad Rafique and Tawfiq Alsulami: reviewing, editing and submission.

Conflict of Interest

The authors declare that they have no conflict of interest.

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