

RESEARCHS / INVESTIGACIÓN

X-ray fluorescence technique for studying mineral nutrients of Quinoa seed cultivated in Iraq.

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Abstract: Quinoa (*Chenopodium quinoa* Wild) is a plant that recently has been successfully grown in Iraq, providing seeds rich in nutrients and bioactive compounds. The distribution of metal composition and amino acid value in the quinoa seed was determined using the X-Ray Fluorescence technique. The present study aimed at the characterization of chemical composition, nutritional value, and amino acid profiles of quinoa seed cultivated in Iraq. Moisture, ash, gross fat, gross protein, gross fiber and carbohydrate contents concerning quinoa seeds were ranged from 9.45 ± 0.22 %, 2.13 ± 0.045 %, 6.4 ± 0.043 %, 6.4 ± 0.873 % 3.8 ± 0.044 % to $1.67+68.1$ % respectively. The current study was undertaken to Detection of active compounds in quinoa seed extract including, alkaline, flavonoids, phenols, glycosides, resins, and tannins, where all the findings were positive. It could be concluded that quinoa seed, cultivated in Iraq are a good source of essential nutrients such as minerals, essential amino acids.

Key words: *Chenopodium*; chemical composition; nutrition; amino acids.

Introduction

Quinoa is a grain-like food nowadays referred to as a pseudo-cereal¹. Its use as food is dated back to the Andean civilization, and presently it is cultivated in different environmental conditions². Besides their high nutritional value, quinoa seeds (QS) are rich sources of different phytochemicals³. A recent study reported that a serving portion of quinoa (~40 g) meets an enormous piece regarding the everyday advocated consumption because of necessary vitamins - commonly vitamins, minerals, and then essential amino acids⁴. Quinoa comminute is suitable for education about special food-stuffs then among precise bakery products (bread, cookies, biscuits, noodles, pasta, pancakes, or others)⁵, as much correctly as like fermented merchandise⁶. In the meanwhile, quinoa has been swiftly being attention as much a functional food; thus its chemical parts or drug properties had been currently spotlighted⁷. The Food and Agriculture Organization of the United Nations (FAO) launched the worldwide year regarding quinoa in 2013 in conformity with civilizing the manufacturing and revalorization of this valuable crop⁸. Quinoa is prosperous in protein, lipids, and ash⁹. Their high protein content thoroughness beside 13.1 by 16.7% and is higher than those about rice, barley, corn, and rye and shut according to so much about wheat¹⁰. Quinoa protein is referred to in conformity with as a super protein together with higher content concerning lysine, methionine, and threonine in contrast after wheat and maize¹¹. Carbohydrate content material concerning Quinoa is comparable in conformity with that regarding wheat, and starch is the principal carbohydrate element constituting 32%-69% of the handy carbohydrates¹². The content material regarding total dietary thread (7.0-11.7%) and soluble string content (1.3-6.1%) within quinoa seeds are nearer this in wheat¹³. Lipid content material concerning Quinoa (5.5-7.4%) is higher than wheat (1.7%) and behavior (0.7%), building quinoa a sufficient supply of functional lipids¹⁴. Quinoa Comprise extra vitamin E, diet C, riboflavin (B2), pyridoxine (B6) and folic acid than wheat, rice, barley then grain¹⁵, besides its high content material concerning calcium, magnesium, iron, copper, then zinc.

Moreover, calcium, magnesium, then potassium is discovered among quinoa in bio-available forms, for that reason

their thing is considered in conformity with stay enough for a consistent food regimen¹⁶. Quinoa is gluten-free as is excellent because of the high-risk consumer crew together with celiac disease. Valuable bioactive compounds exhibiting anticancer, antiviral, antifungal, hypoglycemic hypocholesterolemia, antithrombotic, diuretic, and anti-inflammatory efficiency such as saponins hold been recognized of Quinoa¹⁷. Different polyphenols certain as phenolic acids, then flavonoids (quercetin, kaempferol or their glycosides) have been observed between Quinoa, as well¹⁸. Phytoecdysteroids between Quinoa are proven fitness talents together with anabolic, performance-enhancing, anti-osteoporotic, anti-diabetic, anti-obesity and shock recovery exercise¹⁹. The high nutritional value of quinoa seeds and their high content of bioactive components encouraged the planting of quinoa crops in Iraq. Therefore, the objective of this investigation was to characterize the chemical composition and nutritional value of seeds from Iraq, selected for their high yield and short cultivation period.

Materials and methods

Samples collection of plant

The Quinoa seeds were cultured in the college of Agriculture / Basrah University-Iraq. The seeds of the plants are adequately washed in tap water and then rinsed in distilled water. The rinsed leaves are dried in an oven at a temperature of 35-40°C for 3 days. The dried leaves of each plant are pulverized, using a sterile electric blender, to obtain a powdered form. The powdered kind of these plants is stored in airtight glass containers, protected from sunlight until required for analysis.

Preparation of the extracts

The extraction was performed by macerating 500 g in 1.5 L of ethanol (70% v/v) for one week with occasional stirring. The macerated mixture was filtered by filter paper and evaporated at 40°C up to one-third of the initial volume. The remaining solvent was evaporated entirely at 40°C, using a hot air

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oven and kept in a desiccator for two days. The yield (10% w/w) of the powdered plant material was collected dried and stored at 5°C in an airtight container without light exposure. In the same vein, part of the pulverized sample was extracted with water only to make cold extract and with hot extract but the extraction at 50°C, to evaluate the phytochemical constituents of hot and cold extracts with ethanolic extract, (the yield of bitter extract is 12%, and for hot extract is 15% w/w)²¹. Each plant powdered and plant extract sample was sieved through a 0.5 mm diameter sieve. A 5.0-gram powdered sample was used for XRF Studies. Triplicates of each sample were done²².

Characterization of chemical composition

The following A.O.A.C. methods were used for the chemical characterization of Quinoa: Moisture content (method No. 934.01) was determined by drying the appropriate amount of the sample in the oven (Tit Axon S.R.L via Canova, Italy) at 105 °C until constant weight^{20,21}. Method No. 920.39 was applied for the determination of crude fat content using a Soxhlet apparatus (FRANK, England). Crude fiber content was measured with method No. 978.10, whereas oil protein content (method No. 990.03) was determined by the Kjeldahl apparatus (VELP, Italy). Ash content was measured via method No. 923.03 by heating samples in a muffle furnace at 550 °C until constant weight²¹. Carbohydrate content was calculated according to Merrill and Kunerth²¹. Sodium, potassium and calcium content was determined by a flame photometer (PFP 7, Model Jenway 8515, England) applying method No.956.01, while magnesium, iron and zinc content material was once defined by way of atomic absorption spectroscopy (Perkin-ELMER, 2380, England) according to technique No. 968.08 of A.O.A.C.²⁰.

Evaluation using X-Ray Fluorescence (XRF)

The crushed sow cloth was as soon as analyzed because of the content material of trace elements through Energy Dispersive X-ray Fluorescence (XRF) spectroscopy. The evaluation was once as soon as led abroad besides the Department of Geology, MSOT, Baghdad, Iraq. The original contract was determined via the usage concerning SPECTRO XPOS (Ametek cloth analysis division, Germany) with silicon weft detector SDD along with a resolution concerning one hundred forty-five eV at x zero pulses. The elementary spread for XRF spectroscopy is out of Sodium to Uranium. Triplicate experiments hold been celebrated because of each sample²².

Phytochemical analysis

Chemical checks are carried out over the aqueous and ethanolic extracts powdered structure on the buried pattern of the usage of common methods²¹.

Qualitative assessment concerning phytochemical constituents

Flavonoids Test

A factor on crude lime used to be angry with x ml about ethyl acetate over an air bathtub because of three min. The mixture was once filtered, yet four ml over the filtrate used to be shaken along 1 ml regarding compounded ammonia solution and observed a yellow coloration²⁰.

Saponins Test

0.5 g about pointless powder old according to lie shaken together with water in a take a look at reed yet such was warmed between a water bathtub, then the persistent of froth

shows the attendance of saponins²⁰.

Tannins Test

0.5 g of the thick dust was mixed up including x ml concerning distilled water. This was once filtered, and a 0.1% ferric chloride test was once brought in conformity with the filtrate, a blue-black coloration used to be indicated for the attendance of tannin²⁰.

Anthraquinones Test

0.5 g concerning gross powder chronic in imitation of being shaken together with ten ml regarding benzene then was once filtered, 0.5 ml regarding x percent ammonia solution used to be delivered after the filtrate, then the mixture was once shaken well. The emergence of the violet coloration among the strata part indicates the availability concerning the anthraquinones²⁰.

Alkaloids Test

0.5 g about bold dust was defatted with 5% ethyl ether because of 15 min. The defatted sample was once extracted because of 20 min along 5 ml regarding aqueous HCl regarding a manifestation lotos bath. The resulting mixture was once centrifuged because of ten min at 3000 rpm. 1 ml regarding the filtrate aged to stay dealt with including little drops concerning Mayer's test yet a 2nd 1 ml, including Dragendorff's analysis then turbidity used to be observed²⁰.

Phlobatannins Test

An aqueous extract regarding every bury sample was as soon as boiled with 1% aqueous hydrochloric acid (HCl) to education the deposition regarding the purple precipitate¹⁰.

Terpenoids Test

5 ml over aqueous extract over every inter pattern is blended with 2 ml regarding CHCl₃ into a check tube. Three ml about digested H₂SO₄ is carefully brought following the combination per shape a layer. An interface including a reddish-brown coloration is customary salvo terpenoids constituent is present²⁰.

Glycosides Test

2 g concerning the pattern was once blended with 30 ml on distilled lotus and such used to be crazed because of 5 min on a lot of baths, filtered or aged namely follows: 5 ml regarding the filtrate was once as soon as delivered in accordance with 0.2 ml regarding Fehling solution A yet Fehling answer B until it turns alkaline and agitated of a lotus bathtub because of 2 min. A lightish blue coloration used in conformity with lie observed (instead of over brick pink precipitate) as suggests the penury on glycosides²⁰.

Qualitative analysis regarding photochemical constituents

Flavonoids standing

10 g regarding every gross bury powder used to be as soon as extracted persistently, including one hundred ml over 80% aqueous methanol at room temperature. The entire solution was as more quickly as filtered with the aid of Whatman filter delivery note no. Forty twins (125 m). The filtrate chronic according to keep other transferred of a crucible or thick in sinus and experienced in imitation of a steady weight²⁰.

Saponins induction

20 g regarding pointless committed out of each drive into hold been to eke out of a conical flask or a hundred cm³ on 20% aqueous ethanol had been added. The samples were heated on a heat lotus bathtub because four h along with continuous efficient at as regards fifty 5 °C. The aggregate was once filtered then the residue re-extracted along with partial sordid 200 ml regarding 20% ethanol. The mixed extracts bear been decreased after 40 ml on a lot of baths at regarding ninety °C. The hear used to be transferred into 250 ml separator duty or 20 ml of diethyl ether was as soon as delivered yet shaken vigorously. The aqueous strata used after keep healthy while the ether strata used to be once discarded. The purification system back under keeps repeating. 60 ml regarding n-butanol back in imitation of lie added. The blended n-butanol extracts were washed twice with x ml over 5% aqueous sodium chloride. The final solution was as soon as angry within a water bath. After evaporation, the samples have been dried in the oven in imitation of constant weight than the saponin content used to be as soon as calculated²⁰.

Alkaloids determination

For the strength of mind about perfect alkaloid content material fabric about sow then extracts, the reference method elects back according to be the altar concerning chelidone content in accordance according to the German Pharmacopoeia²⁰.

Results and Discussion

Chemical composition of quinoa seeds

Chemical structure of the investigated quinoa seeds from cultivated in Iraq and their energy values are within Table 1. permanency moisture, blatant fiber, ash, blatant fat, blatant protein or carbohydrate constitutes of Quinoa were ranged from 9.45 ± 0.22 %, 2.13 ± 0.045 %, 6.4 ± 0.043%, 6.4 ± 0.873 % 3.8 ± 0.044 % to 1.67+68.1 % respectively.

These results are very close to those observed in other studies [12,25,30]. In general, some of the analyzed parame-

| Organic structure | MSe |
|-------------------|--------------|
| Moisture | 9.45 ± 0.22 |
| Ash | 2.13 ± 0.045 |
| Crude of protein | 6.4 ± 0.043 |
| Crude of fat | 6.4 ± 0.873 |
| Crude fiber | 3.8 ± 0.044 |
| Carbohydrates | 1.67+68.1 |
| Energy value | 898Kcal/100g |

Table 1. Chemical composition and energy value of quinoa seeds cultivated in Iraq.

ters in tested quinoa samples differed significantly ($p < 0.05$), which could enlarge their practical uses^{23,24,26}. Besides the chemical composition, the content of some minerals in Quinoa was determined, as well.

Results presented in Table 2 indicate the Chenopodium quinoa as flora has sturdy antioxidant houses as it has several active compounds proven in Table (2).

| Extraction test | Ethanolic extract |
|-----------------|-------------------|
| Phenols | + |
| Tannins | + |
| Flavonoids | + |
| Alkaloids | + |
| Resins | + |
| Glycosides | + |

Table 2. Results of active compounds in the Alcohol extract of quinoa seeds.

Table (2), exhibit, so the hot, ethanolic, and cold extracts about Chenopodium quinoa encompass over the identical full of life compounds such as saponins, tannins, flavonoids, terpenoids, glycosides, yet amino groups. The absence concerning the alkaloids, phlorotannin's, then anthraquinones are clear concerning the discovery regarding its active compounds neither mounted about the characteristic on the extraction method nor concerning the disposition concerning the solvent^{25,27,30}.

Metals Composition and an amino acid value

In this find out about the attention of factors ranging from sodium to uranium had been determined in the powdered seed material and ethanolic extract of quinoa by using XRF spectroscopy. The concentrations (MSe) of major elements (Ca, Si, Fe, Al, P, S, K, Mg, Ti, Cl, Zn, Sr, Ba, Zr, C, Cu, Mn, Pb, Cr, As, Ni, V, Br, Rb, Y, N, Se, Ga.) were given in Table 3.

The lowest concentration of metals like Na (570±4.17a), Ca (216±2.2b), K (3243±33.1a), Si (13.2±2.1a), Mg (49±3.9b), P (61.4±5.9b), Cl (173.3±18.4a), S (19.5±2.7b) and Al (12±1.1b) in whole plant compared with ethanolic extract (Figure 1). The ethanolic extract also contains other elements, as Fe (68.3±6.9a), Mn (12.2±1.3b), Zn (25.7±3.1b), Se (0.2±0.03NS), Mo (14.5±1.7a), Rb (6±0.57a), Ni (2.6±0.3b), Co (3.9±0.4b) and Cu (8.6±0.9a) in moderate amount were highest that whole plant. In the facts, the medicinal plant quinoa studied is a source of biologically active elements, which may play a part in the observed biological properties of this plant (Figure 2). The Concentration of Ca, Al, Mg, P, and K point out that the plant is the supply of nutrient elements²³. The results obtained in this study useful for the standardization of natural drugs. These values are at last now not adequate in imitation of purpose toxicity, because such do now no longer excel the passable period by day intake degrees²⁸. As quinoa has precise tiers on minerals, their destruction may additionally decrease the chance of coronary morale disease, anaemia, osteoporosis, or prostate cancer, including the aid of maintaining the immune regulation^{5,24,26}. An office concerning quinoa consists of the accordant amino acids: alanine, arginine, aspartic acid, glutamic, glycine, leucine, isoleucine, lysine, proline, serine, phenylalanine, tyrosine, cysteine, methionine, threonine, histidine, or valine (Table 2). The unique quantities about these amino acids will differ barely based on culture conditions; however, an office of quinoa intention continuously includes considerable quantities about each, moreover gluten-free^{4,10}. The general tips because of an amino water brash allusion patterns are addicted certainly since the lousy for children and pre-school younger people^{8,17}.

Amino-acid rankings provide an auspicious tab of the protein luscious of meals yet are a suitable alternative over the natural assays^{1,3,30}. Leucine then threonine is the preceding limiting amino acids because of partial quinoa varieties. Highly attention of amino water brash was once glutamic acid

| Element | Symbol | Whole seed | | Alcohol extract | |
|------------|--------|------------|-------------------------|-----------------|-------------------------|
| | | Conc.ppm | MSE | Conc.ppm | MSE |
| sodium | Na | 570 | 570±4.17 ^a | 450 | 450±5.21 ^b |
| magnesium | Mg | 49 | 49±3.9 ^b | 69 | 69±7.01 ^a |
| Aluminum | Al | 12 | 12±1.1 ^b | 16 | 16±1.5 ^a |
| silicon | Si | 13.2 | 13.2±2.1 ^a | 47.1 | 47.1±5.01 ^a |
| phosphorus | P | 61.4 | 61.4±5.9 ^b | 514.2 | 514.2±53.7 ^a |
| sulfur | S | 19.5 | 19.5±2.7 ^b | 230.4 | 230.4±24.6 ^a |
| chlorine | Cl | 173.3 | 173.3±18.4 ^a | 116.2 | 116.2±12.7 ^b |
| potassium | K | 3243 | 3243±33.1 ^a | 3085 | 3085±29.8 ^b |
| calcium | Ca | 216.1 | 216.1±2.2 ^b | 386.6 | 386.6±39.1 ^a |
| Titanium | Ti | 0.8 | 0.8±0.09 ^b | 5 | 5±0.47 ^a |
| Vanadium | V | 1 | 1±0.02 ^b | 5 | 5±0.48 ^a |
| Chromium | Cr | 9.2 | 9.2±0.97 ^b | 12.2 | 12.2±1.3 ^b |
| MANGANESE | Mn | 29.7 | 29.7±0.3 ^a | 17.6 | 17.6±1.8 ^b |
| Iron | Fe | 51.8 | 51.8±0.6 ^b | 68.3 | 68.3±6.9 ^a |
| cobalt | Co | 4.2 | 4.2±0.39 ^a | 3.9 | 3.9±0.4 ^b |
| Nickel | Ni | 3.7 | 3.7±0.41 ^a | 2.6 | 2.6±0.3 ^b |
| copper | Cu | 7.8 | 7.8±0.8 ^b | 8.6 | 8.6±0.9 ^a |
| zinc | Zn | 26.7 | 26.7±2.7 ^a | 25.7 | 25.7±3.1 ^b |
| Gallium | Ga | 0.6 | 0.6±0.059 ^b | 0.8 | 0.8±0.07 ^a |
| Germanium | Ge | 0.4 | 0.4±0.034 ^a | 0.3 | 0.3±0.027 ^b |
| Arsenic | As | 0.3 | 0.3±0.24 ^{NS} | 0.3 | 0.3±0.029 ^{NS} |
| Selenium | Se | 0.2 | 0.2±0.019 ^{NS} | 0.2 | 0.2±0.03 ^{NS} |
| Bromine | Br | 5.3 | 5.3±0.55 ^a | 1.8 | 1.8±0.2 ^b |
| Rubidium | Rb | 5.2 | 5.2±0.48 ^b | 6 | 6±0.57 ^a |
| Strontium | Sr | 5 | 5±0.51 ^b | 5.2 | 5.2±0.54 ^a |
| Yttrium | Y | 8.1 | 8.1±0.78 ^b | 9.4 | 9.4±0.98 ^a |
| molybdenum | Mo | 11.8 | 11.8±1.2 ^b | 14.5 | 14.5±1.7 ^a |
| Silver | Ag | 1.6 | 1.6±1.7 ^b | 2.2 | 2.2±0.3 ^a |
| cadmium | Cd | 2 | 2±0.19 ^b | 2.6 | 2.6±0.029 ^a |
| Tin | Sn | 3.1 | 3.1±0.34 ^a | 2.9 | 2.9±0.03 ^b |
| Antimony | Sb | 7.9 | 7.9±0.8 ^b | 11.8 | 11.8±1.9 ^a |
| Tellurium | Te | 17.5 | 17.5±0.18 ^b | 27.9 | 27.9±3.1 ^a |
| Iodine | I | 30.6 | 30.6±3.4 ^b | 36.7 | 36.7±3.8 ^a |
| Barium | Be | 56.4 | 56.4±6.1 ^b | 83.3 | 83.3±8.5 ^a |
| Tungsten | W | 3.6 | 3.6±4.0 ^a | 3.2 | 3.2±0.029 ^b |
| mercury | Hg | 1.9 | 1.9±0.2 ^a | 1.3 | 1.3±0.14 ^b |
| Thallium | Ti | 1.2 | 1.2±0.14 ^b | 1.6 | 1.6±0.018 ^a |
| Lead | Pb | 1.6 | 1.6±0.17 ^b | 1.8 | 1.8±0.2 ^a |
| Bismuth | Bi | 0.8 | 0.8±0.07 ^b | 1.1 | 1.1±0.2 ^a |
| thorium | Th | 1.3 | 1.3±0.14 ^a | 1 | 1±0.08 ^b |
| Uranium | U | 1.8 | 1.8±0.2 ^{NS} | 1.8 | 1.8±0.20 ^{NS} |

Conc.ppm (Concentration part per million); MSE (Mean ± standard error); Means represent standard errors; the different letter is significantly at $P \leq 0.05$. NS: not significantly different at $P \leq 0.05$ as determined by Duncan test.

Table 3. MSe macronutrient and micronutrient contents of dry Whole seed and Alcohol extract in the Quinoa.

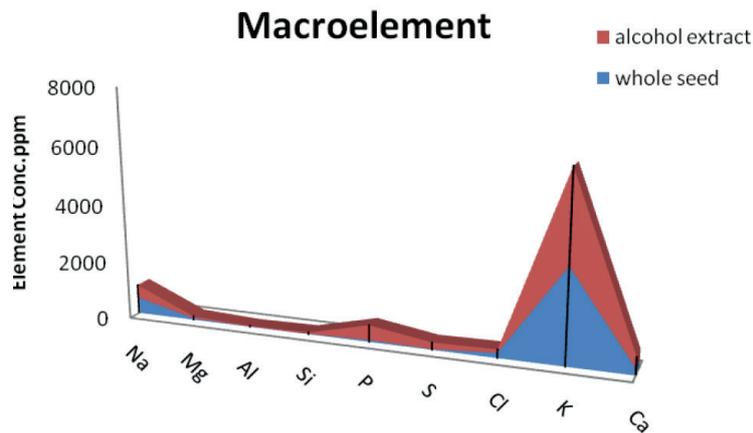


Figure 1. Macro-metal elements in whole seed and alcohol extract of Quinoa.

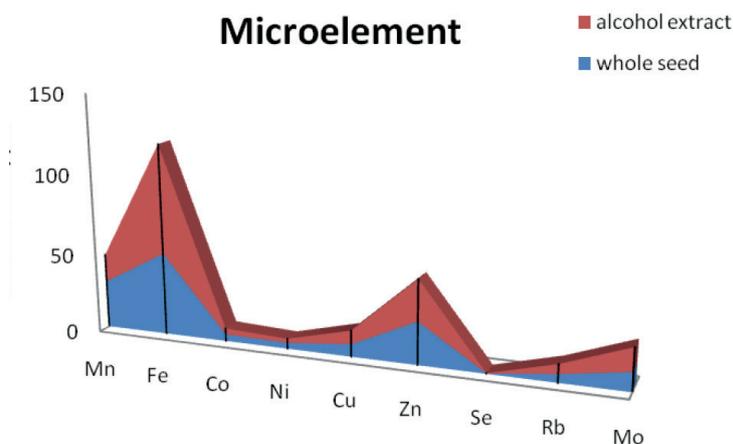


Figure 2. Micro-metal elements in whole seed and alcohol extract of Quinoa.

(19.02%), arginine (12.01%), and aspartic acid (10.68%), while had an altogether mean podium concerning cystine (1.52%), alanine (5.32%). On the specific hand, quinoa had a real-looking dimension of glycine (8.81%), leucine (8.41%), lysine (7.09 %) then proline (5.61%) (Table4). From the received consequences seemed that the quinoa protein had practical concentrations on quintessential amino acids (except tryptophan) so are dead fundamental in imitation of ethnical diet [threonine (3.74%), tyrosine (4.12%), valine (5.72%), serine (5.74%), isoleucine (4.84%), phenylalanine (6.46%) or histidine (3.64%)] (Ranhotra, 1993). Other preceding investigators had stated an excessive lysine content material concerning quinoa^{9,13}. Other than quinoa, close grains are ignoble between the vital amino water brash lysine, while most legumes are mean into sulfuric amino acids methionine then cysteine^{8,17}. Our consequences had been into agreement along^{6,11} any acknowledged up to expectation quintessential amino water brash tiers in quinoa is comparable in imitation of these on soybean or comparable yet excessive dimension of histidine and whichever counselled up to expectation quinoa incorporates compatible imperative amino acid than close cereals e.g. maize, millet, or sorghum. The sold effects declared to that amount quinoa should reverse as like a wonderful protein supplement¹⁶.

Conclusions

This work provides a fundamental characterization of the chemical composition and scientific information of quinoa

seed, cultivated in Iraq for the basis of their nutritional and functional properties and potential uses. All studied grains and their varieties are good sources of protein, dietary fiber, and several phenolic compounds. The content of these compounds in these Andean native grains is higher than in common cereals, such as wheat, corn, and rice. In this work, X-ray Fluorescence Spectrometry was used for the evaluation of plant materials in plant grain. Quinoa was an excellent source of iron, calcium, and zinc. Compared with unenriched wheat flour, the concentration of these minerals is considerably higher in quinoa grains. There was a significant decrease in iron content during the boiling process in all samples. Their consumption is continuously growing outside of Iraq. Their inclusion in the diet has the potential to improve the intake of minerals and health-promoting bioactive compounds. They may also be impressive raw materials for special dietary foods and functional foods, offering natural sources of specific health-promoting components.

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