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 % and 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 acids. Quinoa comminute is suitable for education about special food-stuffs then among precise bakery products (bread, biscuits, noodles, pasta, pancakes, or others)⁴, as much correctly as like fermented merchandise⁵. In the meanwhile, quinoa has been swiftly being attention as much a functional food; thus its chemical parts or drug properties had been currently spotlighted⁶. 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 crop⁷. Quinoa is prosperous in protein, lipids, and ash⁸. Their high protein content material 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 wheat⁹. 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 maize¹⁰. 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 carbohydrates¹¹. The content material regarding total dietary carbohydrate (70%-11.7%) and soluble string content (1.3-6.1%) within quinoa seeds are nearer this in wheat¹². 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 lipids¹³. Quinoa Comprise extra vitamin E, diet C, riboflavin (B2), pyridoxine (B6) and folic acid than wheat, rice, barley then grain¹⁴, 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 regimen¹⁵. Quinoa is gluten-free as is excellent because of the high-risk consumer crew together with celiac disease. Valuable bioactive compounds exhibiting anti-inflammation, antiviral, antifungal, hypoglycemic hypocholesterolemia, antithrombotic, diuretic, and anti-inflammatory efficiency such as saponins hold been recognized of Quinoa¹⁶. Different polyphenols certain as phenolic acids, then flavonoids (quer cetin, kaempferol or their glycosides) have been observed between Quinoa, as well¹⁷. Phytoecdysteroids between Quinoa are proven fitness talents together with anabolic, performance-enhance, anti-osteoporotic, anti-diabetic, anti-obesity and shock recovery exercise¹⁸. 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...
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 weight20,21. 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 ºC until constant weight21. Carbohydrate content was calculated according to Merrill and Kunerth21. Sodium, potassium and calcium content was determined via the usage of SPECTRO XPOS (Ametek cloth analysis division, Germany) with silicon weft detector determination was once led abroad besides the Department of Geology, MSOT, Baghdad, Iraq. The original contract was delivered in accordance with the strata part indicates the availability concerning the anthraquinones20.

Saponins Test

0.5 g of the thick dust was dispersed among 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 lotus 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.

Glycosides 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.

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.

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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 coloration25.

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.
Saponins induction

20 g regarding pointless committed out of each drive into hold been to eke out of a conical flask or a hundred cm² 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 ºC. 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 ºC. 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 chelidonine content in accordance according to the German Pharmacopoeia29.

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-

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

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

| Phenols    | +    |
| Tannins    | +    |
| Flavonoids | +    |
| Alkaloids  | +    |
| Resins     | +    |
| Glycosides | +    |

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 solvent26,27,30.

Metals Composition and an amino acid value

In this find out about 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, Cr, Zn, Sr, Ba, Zr, C, Cu, Mn, Pb, Cr, As, Ni, V, Br, Rb, Y, 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 (48±3.9b), P (61.4±5.9b), Cl (173.3±18.4a), S (19.5±7.2b) and Al (12±1.1b) in whole plant compared with ethanolic extract (Figure 1). The ethanolic extract also contains other elements, as Fe (88.3±6.9a), Mn (12±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 elements29. 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 regula-

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 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-

Results presented in Table 2 indicate the Chenopodium quinoa as flora has sturdy antioxidant houses as it has several chemical composition, the content of some minerals in Quinoa which could enlarge their practical uses23,24,26. Besides the amino water brash allusion patterns are addicted certainly 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-

Amino-acid rankings provide an auspicious tab of the protein luscious of meals yet are a suitable alternative over the natural assays24,26. Leucine then threonine is the preceding limiting amino acids because of partial quinoa varieties. High-

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

| Extraction test | Ethanolic extract |
|-----------------|-------------------|
| Phenols         | +                 |
| Tannins         | +                 |
| Flavonoids      | +                 |
| Alkaloids       | +                 |
| Resins          | +                 |
| Glycosides      | +                 |
Table 3. MSe macronutrient and micronutrient contents of dry Whole seed and Alcohol extract in the Quinoa.

| 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\(^b\)  | 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\(^a\) |
| 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±0.02\(^b\) |
| Arsenic      | As      | 0.3        | 0.3±0.24\(^NS\) | 0.3         | 0.3±0.02\(^NS\) |
| 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±0.02\(^a\) |
| 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±0.02\(^b\) |
| 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\(^b\)  | 1           | 1±0.08\(^b\) |
| Uranium      | U       | 1.8        | 1.8±0.2\(^NS\)  | 1.8         | 1.8±0.20\(^NS\) |

\(\text{Conc.ppm} \) (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 \(P=0.05\) as determined by Duncan test.
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(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%) (Table 4). From the received consequen-
ces seemed that the quinoa protein had practical concentra-
tions 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%), iso-
leucine (4.84%), phenylalanine (6.46%) or histidine (3.64%)} (Ranhotra, 1993). Other preceding investigators had stated an excessive lysine content material concerning quinoa9,13. 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 cysteine8,17. 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.

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 com-
pounds in these Andean native grains is higher than in common
cereals, such as wheat, corn, and rice. In this work, X-ray Flu-
orescence 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 im-
pressive raw materials for special dietary foods and functional
foods, offering natural sources of specific health-promoting
components.

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