

Investigation of Some Quinoa (*Chenopodium Quinoa*) Genotypes in Terms of Quality Criteria

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ABSTRACT: Quinoa is a rapidly growing plant in the world in the last 20 years. The main reasons for this are that the nutritional contents are important for human health and food benefits. In this study, some quality criterion contents (Moisture, protein, saponin, fat, vitamin C, vitamin B, amino acid, mineral substance) of 20 genotypes belonging to quinoa, which is considered as a new plant for our country, were examined. Protein content is between 12.07% -13.19%, saponin content is between 0.82-1.87%, fat content is between 5.7-6.3%, vitamin C content is between 4.62-10.3 (mg kg⁻¹), changed.

Keywords: Quinoa, Protein, Saponin, Nutrient content

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INTRODUCTION

Quinoa, a so-called “superfood”, is considered as the most nutritious grain in the world. It has a variety of uses in the food, feed, food processing and other non-food/industrial uses. Quinoa is one of the main food crops in Latin America but recently has raised interest in North America, Europe, and Asia (AAFRD, 2005).

Quinoa is originally from the Andes region in South America. It is seen as the most nutrient-dense 'grain' in the world, because of its protein quality (amino acids pattern), minerals and vitamin content. Other great features of quinoa are gluten-free and low glycemic index (NIFS, 2012).

Yazar et al. (2015) reported that quinoa was introduced in Turkey for the first time in 2008 as part of a European Union project within the seventh framework programme titled “Sustainable water use securing food production in dry areas of the Mediterranean region”.

Quinoa plants can be used to nutrification for humans and animals by eaten both seeds and leaves. Quinoa is also very beneficial for digestion as it contains twice as much nutrient fiber as other cereal products. Effects of quinoa added to rations of feed; It can vary depending on the chemical structure, quantity, and characteristics of the animals (Balcı and Çetin, 2017).

Since quinoa does not contain gluten, it can be used as a food source that meets the protein and carbohydrate needs of celiac patients (Bilgiçli and İbanoğlu, 2015).

Table 1: Pre-washed quinoa nutritional content values reported by USDA.

| Nutrient | Unit | Cup 45 g | Value per 100 g |
|--------------------------------|-------------|-----------------|------------------------|
| Proximates | | | |
| Energy | kcal | 160 | 356 |
| Protein | g | 6.00 | 13.33 |
| Total lipid (fat) | g | 2.50 | 5.56 |
| Carbohydrate, by difference | g | 30.00 | 66.67 |
| Fiber, total dietary | g | 2.0 | 4.4 |
| Sugars, total | g | 2.00 | 4.44 |
| Minerals | | | |
| Calcium, Ca | mg | 20 | 44 |
| Iron, Fe | mg | 2.70 | 6.00 |
| Sodium, Na | mg | 10 | 22 |
| Vitamins | | | |
| Vitamin C, total ascorbic acid | mg | 0.0 | 0.0 |
| Vitamin A, IU | IU | 100 | 222 |
| Lipids | | | |
| Fatty acids, total saturated | g | 0.000 | 0.000 |
| Fatty acids, total trans | g | 0.000 | 0.000 |
| Cholesterol | mg | 0 | 0 |

USDA 2019

The seeds can be cooked like rice and used in salads, soups, and curries. Quinoa may also be used as an alternative to pasta. When cooked, the seed has a fluffy consistency but it is slightly crunchy to bite. The seed has a mild delicate nutty flavour. Quinoa leaves are also palatable but they are not commonly consumed. The seed and leaves of the quinoa plant contain many bioactive compounds that have antioxidant, anti-allergic, anti-inflammatory, antiviral and anticarcinogenic properties. The nutritional significance of quinoa is that it is one of the plant foods that contains all essential amino acids. Quinoa contains its amino acids within the seed (in the embryo), which is the consumed portion

of the seed. This is unlike other staple grains such as rice and wheat that contain amino acids in the hull of the grain and therefore, they are lost during de-hulling or de-husking. Quinoa does not contain gluten, which is another feature that has attracted much interest in recent years (Kealey, 2017).

Leaves, stems and grains are used in alternative medicine for different purposes. Saponin found in plants and seeds has the potential to be used in pharmaceutical production, pesticide production and food industry (Zurita-Silva et al., 2014).

Nutrient content of quinoa in general

Wright et al. (2002) stated that protein content of quinoa grains varies between 7 and 22%. Seeds with a balanced protein content in terms of essential amino acids are considered an ideal source of nutrition. Lysine (5.1–6.4%) and Methionine are rich in amino (0.4–1.0%) acids that are missing in cereals. Besides a balanced amino acid content, it is rich in vitamins and especially mineral substances such as calcium, iron and phosphorus (Vega-Gálvez et al., 2010). Koziol (1992) reported that 51% to 61% of the starch in grain. Because of its high viscosity, it is used in starch industry (Galwey et al., 1990).

Table 2: Comparison of selected nutritional qualities in quinoa and other grains, including proteins, vitamin B1, Fe and Ca minerals

| Type of grain | Proteins g in 100 g (%) | Vit B1 (mg 100 g ⁻¹) | Fe (ppm) | Ca (ppm) |
|---------------|-------------------------|----------------------------------|----------|----------|
| Quinoa | 9-16 | 0.39 | 133 | 1200 |
| Wheat | 12.6 | 0.3 | 40 | 360 |
| Maize | 9.4 | 0.3 | 25 | 100 |
| White rice | 6.7 | 0.08 | 4.6 | 40 |
| Millet | 11.0 | 0.3 | 30 | 201 |
| Soybean | 36.5 | 0.9 | 157 | 2770 |
| Sunflower | 22.8 | 1.9 | 6.3 | 38 |
| Sorghum | 11.3 | 0.34 | 45 | 260 |

Source: Martinez 2015

Quinoa seed is a highly nutritious human food. It is a relatively good source of minerals such as protein, calcium, iron and vitamins E and B. All 8 essential amino acids required for tissue development in humans are found in the seed of this plant. Methionine amino acids, which are low in lysine, cysteine and other grains, are also extremely high. Therefore, quinoa is considered to be a great source of protein (Repo Carrasco Valencia and Serno, 2011). In the quinoa that contains almost all vitamins such as A, B, C, D and K has not cholesterol (Miranda et al., 2012).

Nutrient contents of quinoa plant are given briefly in United States Department of Agriculture (USDA), Agricultural Research Service, Food Products Database (Table 1). Among quinoa and some other grains comparison nutritional qualities and amounts are given to table 2.

The aim of this study is to determine the quality criteria of kinoa genotypes brought from abroad and to evaluate them in future breeding studies.

MATERIAL AND METHODS

Materials

In 2016 nutritional contents of 20 quinoa genotypes brought from USDA were examined at 2017. The label numbers of the genotypes are given in the table 3.

Table 3: The label names of materials

| No | Genotypes | Name of Label in USDA |
|----|-----------|---|
| 1 | 83-7 | PI 614927 CQ 127 |
| 2 | 85-2 | PI 614928 CQ 130 |
| 3 | 85-3 | PI 614928 CQ 130 |
| 4 | 86-7 | PI 614928 CQ 128 |
| 5 | 124-2 | Sİ 478411 R-67 |
| 6 | 124-5 | Sİ 478411 R-67 |
| 7 | 126-3 | 478415 R-71 |
| 8 | 127-2 | Sİ 478418 R-132 |
| 9 | 127-5 | Sİ 478418 R-132 |
| 10 | 129-1 | PI 510526 ANCCO CCANAHUA(AYMARA) CANİHUA BLANCO |
| 11 | 186-1 | PI 666304 BYU 534 |
| 12 | 187-3 | PI 666316 BYU 520 |
| 13 | 188-2 | PI 666298 BYU 525 |
| 14 | 191-2 | PI 666270 BYU 546 |
| 15 | 192-4 | PI 666322 BYU 548 |
| 16 | 197-1 | AMES28064 BYU 552 |
| 17 | 208 | PI 658755 1022 |
| 18 | 2012-2 | PI 666281 BYU 702 |
| 19 | 215 | PI 666284 BYU 879 |
| 20 | 219-1 | PI 666288 BYU 578 |

Analyses

The moisture content determination was carried out according to Elgün et al. (2002) and AOAC (2005). The determination of crude protein content was carried out by Anonymous 1980's kjeldahl method. Saponin content was determined to the method indicated by Güçlü Üstündağ et al. (2007). The oil content determination was performed by soxhlet method and calculation as stated by Kraujalis et al., (2013). The amounts of B vitamins (as water soluble B1, B2, B3, B5, B6, B7, B9) in quinoa seed were made according to Kırak 2015 in UHPLC-MS / MS device. Vitamin C content was by certification of NBS (N-bromosuccinimide) determined according to Barakat et al. (1955). Free amino acid profile analysis in quinoa seed were made using UHPLC-MS / MS device according to Kırak (2015) method. In the determination of the mineral matter (Mn, Mg, Cu, Fe, Zn, Pb and Cd) of the quinoa seed used in the study, Chaves et al. (2010) as it does, the ICP-MS method was utilized. Mineral contents of the samples in mg kg⁻¹ are given as indicated by Falandysz et al. (2010).

RESULTS AND DISCUSSIN

Content of moisture

The moisture content of the quinoas ranged from 11.96% to 12.91%. All were found to be in storage humidity (Table 4).

Highest moisture content to safe storage; should be for wheat 14%, for corn, barley, oats and sorghum 13%, for rice 12-13% (Hoseney, 1986).

Table 4: Parameter and analysis results

| Genotypes | Moisture (%) | Protein (%) | Saponin % (g 100g ⁻¹) | Oil (%) (in dry matter) |
|-----------|--------------|-------------|-----------------------------------|-------------------------|
| 83-7 | 12.91 | 12.07 | 1.04 | 5.8 |
| 85-2 | 11.96 | 13.05 | 0.82 | 6.2 |
| 85-3 | 12.73 | 12.47 | 1.21 | 5.9 |
| 86-7 | 12.61 | 12.60 | 1.33 | 5.8 |
| 124-2 | 12.83 | 12.60 | 1.09 | 5.9 |
| 124-5 | 12.65 | 12.34 | 1.17 | 6.1 |
| 126-3 | 12.12 | 13.19 | 1.23 | 6.3 |
| 127-2 | 12.31 | 12.59 | 0.95 | 6.2 |
| 127-5 | 12.58 | 12.76 | 1.87 | 6.0 |
| 129-1 | 12.58 | 12.79 | 1.28 | 5.9 |
| 186-1 | 12.45 | 12.43 | 1.17 | 5.7 |
| 187-3 | 12.61 | 12.43 | 1.43 | 5.8 |
| 188-2 | 12.79 | 12.40 | 1.23 | 5.9 |
| 191-2 | 12.76 | 12.91 | 1.10 | 5.9 |
| 192-4 | 12.84 | 12.29 | 1.54 | 5.9 |
| 197-1 | 12.45 | 12.75 | 1.00 | 6.0 |
| 208 | 12.43 | 12.68 | 1.29 | 6.2 |
| 2012-2 | 12.02 | 12.68 | 1.12 | 5.8 |
| 215 | 12.15 | 12.52 | 1.25 | 6.2 |
| 219-1 | 12.63 | 12.34 | 1.32 | 6.3 |
| min. | 11.96 | 12.07 | 0.82 | 5.70 |
| max. | 12.91 | 13.19 | 1.87 | 6.30 |
| mean | 12.52 | 12.59 | 1.22 | 5.99 |
| skewness | -0.68 | 0.39 | 1.07 | 0.38 |
| kurtosis | -0.51 | 0.28 | 2.80 | -1.19 |
| sd | 0.28 | 0.27 | 0.22 | 0.19 |
| CV | 2.24 | 2.14 | 18.40 | 3.11 |

sd: standard deviation CV: coefficient of variation

Content of protein

Crude protein values of quinoa genotypes ranged from 12% to 13% (Table 4). This protein value was found to be the same as the protein amount of wheat (Table 2).

Xu et al. (2019) reported that the protein content (g 100g⁻¹) value of fermented quinoa between 19.34%-28.46%, and which were higher than that of control (159%-234%). Kakabouki et al. (2014) observed greatest crude protein value 27%.

According to other cereals protein content is higher in quinoa. And these proteins are concentrated in the embryo and the majority of their are albumin and globulin (Lindeboom, 2005; Schoenlechner et al., 2008). It has a very good protein quality and can contain between 8-22% protein (Jancurova et al., 2009). The protein ratio shows significant differences between the varieties (Bhargava et al., 2007; Repo Carrasco Valencia and Serno, 2011).

Content of saponin

The quinoa material 85-2 may be suitable as food, and the material 127-5 may be suitable for use in industry. In this study, the amount of saponin ranged from 0.824 to 1.869 (Table 4).

In order to use quinoa as food, it is desirable that the amount of saponin be low. High saponin quinoas are used in the industry. Our quinoa materials were suitable for both food and industrial use.

Saponins possess a broad variety of biological effects as antimicrobial, antioxidant, antiviral, analgesic, antiinflammatory and cytotoxic activity, effect on the absorption of minerals and vitamins and immunostimulatory effects, increased permeability of the intestinal mucosa neuroprotective action, and reduction of fat absorption (Güçlü Üstündağ and Mazza, 2007).

Seeds can be colored in black, orange, pink, red, yellow or white. The seed color is due to the saponin content in the shell (Prego et al., 1998).

The saponin is between 0.14-0.73% in seed, and an anti-nutritional element in the shell of its seed and gives a bitter taste. Before consumption the seed must be removed from its shell because of this bitter taste. (Bhargava et al., 2006; Abugoch, 2009). Brady et al. (2007) reported that the bitter taste by saponins could be reduced by extrusion and roasting processes.

In the quinoa grain, the saponin content is 0.03-2.05% and this ratio is lower than soybean (James, 2009; Schoenlechner et al., 2008). Enriquez et al. (2003) reported that saponin which negatively affects the taste and colour of quinoa, has no negative effect on proteins and especially on amino acid composition.

Content of oil

The oil content of the materials varied between 5.8 and 6.3% in dry matter (refer to table 4). It was seen that the amount of fat was higher than the wheat, barley, oats and rye used as cereals in terms of unsaturated fatty acid and lower than soybean. The fat content of the materials was found to be equivalent to oiled corn grain.

Xu et al. (2019) reported that the crude oil content ($\text{g } 100\text{g}^{-1}$) was between 3.31% and 4.64% and but this rate was 5.64% in unfermented quinoa.

The rate of unsaturated fatty acids is high in Quinoa. Oleic acid forms a large part. Especially omega-6 and omega-3 fatty acids are cannot be synthesized in the human body and they must be obtained from foods (Bayram et al., 2018).

Quinoa also has a rich content of essential unsaturated fatty acids (Park and Morita, 2004). The high fat content and the high antioxidant vitamin-E content in quinoa (approximately 700 ppm α -tocopherol and 840 ppm γ -tocopherol) prevent rapid lipid oxidation (Koziol, 1992). Fat content (6-7%) is higher than cereals (Reichert et al., 1986).

Content of vitamin B

As a result of the analysis, B3 (nicotinamide), B6 (pyridoxamine), B6 (pyridoxal) could not be read below the reporting limit. B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), B9 (folic acid) contents of the readings ranged from 0.256 to 19.205. It was determined by the results of the analysis that was rich in B vitamins. B1, B2, B3, B5, B7, B12 and Folic acid were found but not B6 and Choline (bitartrate) (Table 5).

Quinoa is also rich in microelements such as vitamins. Vitamins E and B (especially folic acid) is also an important source of food (Doğan and Karwe, 2003; Repo Carrasco Valencia et al., 2003; Alvarez Jubete et al., 2010; Vega Galvez et al., 2010). Koziol 1992 and Galwey et al., 1990 reported that 100 g of seeds can meet the daily vitamin B6 and folic acid requirements of children and adults. The riboflavin content at 100 g accounts for 80% of children's daily needs and 40% of adults. Niacin and α carotene are also very rich (Bayram et al., 2018).

Table 5. Amount of vitamin B content in quinoa seeds (mg kg⁻¹)

| Genotypes | B1 thiamine | B2 riboflavin | B3 niasin | B3 nicotinamide | B5 pantothenic acid | B6 pyridoxamine | B6 pyridoxal | B6 pyridoxine | B7 biotin | B9 folic acid |
|-----------|-------------|---------------|-----------|-----------------|---------------------|-----------------|--------------|---------------|-----------|---------------|
| 83-7 | 4.24 | 3.19 | 15.26 | <R.L. | 1.23 | <R.L. | <R.L. | 4.99 | NF | 1.96 |
| 85-2 | 3.59 | 3.15 | 15.37 | <R.L. | 0.55 | <R.L. | <R.L. | 4.60 | NF | 1.78 |
| 85-3 | 3.87 | 3.05 | 15.21 | <R.L. | 1.95 | <R.L. | <R.L. | 5.06 | NF | 1.94 |
| 86-7 | 3.61 | 3.28 | 16.72 | <R.L. | <R.L. | <R.L. | <R.L. | 4.83 | NF | 1.83 |
| 124-2 | 4.36 | 3.50 | 19.21 | <R.L. | 0.25 | <R.L. | <R.L. | 5.43 | NF | 2.03 |
| 124-5 | 3.89 | 3.22 | 15.35 | <R.L. | 0.61 | <R.L. | <R.L. | 4.87 | NF | 1.91 |
| 126-3 | 3.62 | 3.15 | 15.39 | <R.L. | <R.L. | <R.L. | <R.L. | 4.63 | NF | 1.79 |
| 127-2 | 3.37 | 3.18 | 15.86 | <R.L. | <R.L. | <R.L. | <R.L. | 4.41 | NF | 1.69 |
| 127-5 | 3.77 | 3.24 | 16.54 | <R.L. | 1.14 | <R.L. | <R.L. | 5.05 | NF | 1.91 |
| 129-1 | 3.29 | 3.07 | 15.99 | <R.L. | 1.91 | <R.L. | <R.L. | 4.51 | NF | 1.69 |
| 186-1 | 3.14 | 3.15 | 12.05 | <R.L. | <R.L. | <R.L. | <R.L. | 3.83 | NF | 1.54 |
| 187-3 | 3.72 | 3.01 | 14.67 | <R.L. | 1.25 | <R.L. | <R.L. | 4.76 | NF | 1.84 |
| 188-2 | 3.96 | 3.16 | 15.78 | <R.L. | 1.466 | <R.L. | <R.L. | 5.18 | NF | 1.98 |
| 191-2 | 3.02 | 2.70 | 13.31 | <R.L. | <R.L. | <R.L. | <R.L. | 4.04 | NF | 1.53 |
| 192-4 | 3.26 | 3.15 | 16.40 | <R.L. | <R.L. | <R.L. | <R.L. | 4.47 | NF | 1.67 |
| 197-1 | 3.45 | 3.24 | 13.44 | <R.L. | 1.70 | <R.L. | <R.L. | 4.32 | NF | 1.69 |
| 208 | 3.65 | 3.45 | 16.82 | <R.L. | <R.L. | <R.L. | <R.L. | 4.67 | NF | 1.81 |
| 2012-2 | 3.42 | 3.14 | 15.66 | <R.L. | <R.L. | <R.L. | <R.L. | 4.48 | NF | 1.72 |
| 215 | 3.90 | 3.22 | 16.41 | <R.L. | 1.96 | <R.L. | <R.L. | 5.23 | NF | 1.98 |
| 219-1 | 3.90 | 3.13 | 16.33 | <R.L. | <R.L. | <R.L. | <R.L. | 5.35 | NF | 2.00 |
| min | 3.02 | 2.70 | 12.05 | | 0.25 | | | 3.83 | | 1.53 |
| max | 4.36 | 3.50 | 19.21 | | 1.96 | | | 5.43 | | 2.03 |
| mean | 3.65 | 3.17 | 15.59 | | 1.27 | | | 4.74 | | 1.81 |
| skewness | 0.15 | -0.69 | -0.24 | | -0.44 | | | -0.29 | | -0.37 |
| kurtosis | -0.26 | 3.83 | 1.99 | | -1.03 | | | -0.25 | | -0.79 |
| sd | 0.35 | 0.16 | 1.50 | | 0.60 | | | 0.42 | | 0.15 |
| CV | 9.56 | 5.07 | 9.60 | | 46.99 | | | 8.93 | | 8.25 |

<R.L. : Below the Reporting Limit. R.L. : Reporting Limit (0.5 mg kg⁻¹)
 sd: standard deviation CV: coefficient of variation

Content of vitamin C

As a result of the analysis, it was seen that all materials were between 5.32 and 10.30 in terms of vitamin C (mg kg⁻¹), refer to table 6. Vitamin C content seems to be sufficient.

Vitamin C contained in quinoa 4.16 mg 100g⁻¹ available (Ruales and Nair, 1993).

Table 6. Amount of vitamin C content in quinoa seeds (mg kg⁻¹)

| Genotypes | Vitamin C (L-ascorbic acid) |
|-----------|-----------------------------|
| 83-7 | 5.88 |
| 85-2 | 8.03 |
| 85-3 | 5.82 |
| 86-7 | 9.16 |
| 124-2 | 7.12 |
| 124-5 | 8.60 |
| 126-3 | 5.38 |
| 127-2 | 8.45 |
| 127-5 | 6.70 |
| 129-1 | 7.60 |
| 186-1 | 4.62 |
| 187-3 | 8.30 |
| 188-2 | 5.96 |
| 191-2 | 6.89 |
| 192-4 | 5.86 |
| 197-1 | 8.46 |
| 208 | 6.34 |
| 2012-2 | 10.30 |
| 215 | 6.93 |
| 219-1 | 9.01 |
| min | 4.62 |
| max | 10.30 |
| mean | 7.27 |
| skewness | 0.17 |
| kurtosis | -0.68 |
| sd | 1.49 |
| CV | 20.43 |

sd: standard deviation CV: coefficient of variation

Content of amino acid

14 amino acid values were measured in 20 materials. There was no cystine amino acid and serine amino acid (below the reporting limits). In the results, 12 of the basic amino acids contained values ranged from 10.97 to 1133.16. The lowest and highest amino acid values were observed in methionine and aspartic acid. The average values of methionine basic acid ranged from 2.16 to 13.87. The average values found in aspartic acid ranged from 680.67 to 1133.16. Other amino acids varied between these values (Table 7).

Quinoa seed contains all essential amino acids and more than 37% essential amino acids (Koziol, 1992; Lindeboom, 2005; James, 2009). Quinoa containing essential amino acids in a very balanced ratio is also close to milk protein in terms of protein quality (Repo Carrasco Valencia et al., 2003).

Table 7. Amount of amino acids in quinoa seeds (mg kg⁻¹)

| Genotypes | arginine | histidine | lysine | aspartic acid | glutamic acid | cystine | proline |
|-----------|----------|-----------|--------|---------------|---------------|---------|---------|
| 83-7 | 15.91 | 11.08 | 52.66 | 935.40 | 330.23 | <R.L. | 35.76 |
| 85-2 | 13.24 | 14.12 | 50.79 | 972.09 | 382.86 | <R.L. | 22.57 |
| 85-3 | 14.70 | 13.05 | 43.99 | 1036.50 | 397.78 | <R.L. | 12.64 |
| 86-7 | 20.56 | 28.93 | 49.40 | 780.53 | 298.53 | <R.L. | 39.99 |
| 124-2 | 10.97 | 21.43 | 42.95 | 680.67 | 264.87 | <R.L. | 36.23 |
| 124-5 | 18.34 | 21.04 | 37.46 | 850.26 | 345.02 | <R.L. | 42.75 |
| 126-3 | 13.32 | 19.81 | 36.92 | 1085.26 | 213.99 | <R.L. | 24.78 |
| 127-2 | 16.92 | 26.34 | 38.34 | 1098.25 | 330.48 | <R.L. | 16.05 |
| 127-5 | 17.44 | 28.34 | 42.34 | 1056.01 | 414.85 | <R.L. | 17.11 |
| 129-1 | 17.23 | 18.91 | 43.00 | 807.96 | 259.10 | <R.L. | 14.99 |
| 186-1 | 21.72 | 29.34 | 53.19 | 1133.16 | 408.05 | <R.L. | 33.45 |
| 187-3 | 23.13 | 20.51 | 37.97 | 787.72 | 326.25 | <R.L. | 17.52 |
| 188-2 | 23.49 | 27.27 | 46.12 | 917.75 | 390.25 | <R.L. | 44.48 |
| 191-2 | 25.84 | 13.21 | 43.62 | 876.13 | 268.53 | <R.L. | 25.93 |
| 192-4 | 27.97 | 23.80 | 52.96 | 1052.45 | 361.20 | <R.L. | 19.63 |
| 197-1 | 17.93 | 21.81 | 47.77 | 1000.28 | 317.44 | <R.L. | 22.33 |
| 208 | 18.39 | 22.24 | 41.02 | 807.25 | 307.47 | <R.L. | 27.07 |
| 2012-2 | 15.75 | 17.49 | 36.56 | 763.27 | 259.39 | <R.L. | 17.12 |
| 215 | 15.41 | 15.63 | 44.25 | 859.91 | 272.26 | <R.L. | 38.71 |
| 219-1 | 20.14 | 12.97 | 45.48 | 904.95 | 206.46 | <R.L. | 13.23 |
| min | 10.97 | 11.08 | 36.56 | 680.67 | 206.46 | | 12.64 |
| max | 27.97 | 29.34 | 53.19 | 1133.16 | 414.85 | | 44.48 |
| mean | 18.42 | 20.37 | 44.34 | 920.29 | 317.75 | | 26.12 |
| skewness | 0.53 | 0.03 | 0.23 | 0.02 | -0.08 | | 0.42 |
| kurtosis | -0.06 | -1.13 | -1.00 | -1.06 | -0.91 | | -1.27 |
| sd | 4.37 | 5.79 | 5.45 | 129.42 | 62.52 | | 10.50 |
| CV | 23.70 | 28.44 | 12.29 | 14.06 | 19.68 | | 40.20 |

<R.L. : Below the Reporting Limit. R.L. : Reporting Limit (0.5 mg kg⁻¹)
sd: standard deviation CV: coefficient of variation

In general, it is very rich in lysine amino acid, which is present in low amounts in cereals. It also contains a significant amount of methionine and cysteine. In this respect, it is a good complement to many legumes with low methionine and cysteine content (Doğan and Karwe, 2003; Jancurova et al., 2009). The protein activity ratio (PER) is similar to that of casein (Ranhotra et al., 1993). Digestibility (84.3%) was lower than casein (88.9%). The net protein utilization (NPU) value of quinoa proteins is 75.2 and the biological value is 82.6 (Ruales and Nair, 1992).

Table 7. Amount of amino acids in quinoa seeds (mg kg⁻¹) (continue)

| Genotypes | serine | threonine | valine | methionine | tyrosine | leucine+isoleucine | phenylalanine |
|-----------|--------|-----------|--------|------------|----------|--------------------|---------------|
| 83-7 | <R.L. | 39.88 | 135.44 | 4.96 | 25.46 | 50.04 | 55.10 |
| 85-2 | <R.L. | 52.53 | 77.39 | 4.70 | 29.25 | 47.73 | 49.59 |
| 85-3 | <R.L. | 24.86 | 51.54 | 5.78 | 23.54 | 48.29 | 42.73 |
| 86-7 | <R.L. | 25.10 | 45.81 | 8.34 | 22.79 | 38.58 | 39.16 |
| 124-2 | <R.L. | 56.01 | 39.01 | 5.60 | 16.53 | 47.02 | 33.65 |
| 124-5 | <R.L. | 38.48 | 77.64 | 3.55 | 23.70 | 41.47 | 47.55 |
| 126-3 | <R.L. | 22.85 | 62.11 | 3.54 | 37.27 | 41.94 | 53.17 |
| 127-2 | <R.L. | 27.44 | 90.70 | 4.51 | 39.84 | 43.27 | 55.47 |
| 127-5 | <R.L. | 35.94 | 72.76 | 6.41 | 33.13 | 51.70 | 45.23 |
| 129-1 | <R.L. | 27.05 | 65.81 | 2.16 | 26.33 | 35.12 | 42.75 |
| 186-1 | <R.L. | 23.92 | 61.91 | 6.96 | 41.42 | 37.62 | 61.88 |
| 187-3 | <R.L. | 38.42 | 77.23 | 7.57 | 31.01 | 49.10 | 45.64 |
| 188-2 | <R.L. | 35.73 | 66.65 | 9.43 | 44.95 | 36.53 | 75.39 |
| 191-2 | <R.L. | 21.05 | 89.69 | 9.46 | 41.80 | 41.59 | 52.38 |
| 192-4 | <R.L. | 27.09 | 81.21 | 6.68 | 32.64 | 52.92 | 38.87 |
| 197-1 | <R.L. | 32.51 | 78.35 | 7.79 | 42.87 | 52.23 | 43.38 |
| 208 | <R.L. | 36.93 | 90.41 | 7.39 | 34.15 | 37.75 | 50.56 |
| 2012-2 | <R.L. | 44.64 | 38.41 | 13.87 | 24.88 | 60.86 | 49.67 |
| 215 | <R.L. | 43.89 | 61.90 | 11.45 | 26.87 | 57.59 | 48.29 |
| 219-1 | <R.L. | 33.94 | 167.40 | 10.43 | 15.97 | 37.55 | 37.44 |
| min | | 21.05 | 38.41 | 2.16 | 15.97 | 35.12 | 33.65 |
| max | | 56.01 | 167.40 | 13.87 | 44.95 | 60.86 | 75.39 |
| mean | | 34.41 | 76.57 | 7.03 | 30.72 | 45.45 | 48.40 |
| skewness | | 0.64 | 1.65 | 0.56 | 0.05 | 0.42 | 1.15 |
| kurtosis | | -0.15 | 3.67 | 0.24 | -0.94 | -0.71 | 2.51 |
| sd | | 9.79 | 30.45 | 2.91 | 8.63 | 7.40 | 9.38 |
| CV | | 28.46 | 39.76 | 41.34 | 28.10 | 16.28 | 19.39 |

<R.L. : Below the Reporting Limit. R.L. : Reporting Limit (0.5 mg kg⁻¹)

sd: standard deviation CV: coefficient of variation

Content of mineral matter

No toxic lead or cadmium, which is carcinogenic in mineral content. Other mineral substances were found to contain differently. Mn (manganese) from 14.25 to 45.64 mg kg⁻¹, Mg (magnesium) from 1713 to 3068 mg kg⁻¹, Fe (iron) from 65.58 to 530 mg kg⁻¹, Cu (copper) from 5 to 7 mg kg⁻¹, Zn (zinc) ranged from 1.27 to 14.28 mg kg⁻¹ (Table 8).

Tan (2019) reported that Mn from 49.0 to 161.3 mg kg⁻¹, Mg from 962 to 2344 mg kg⁻¹, Fe from 265.9 to 498.6 mg kg⁻¹, Cu from 27.4 to 92.5 mg kg⁻¹, Zn from 41.3 to 85.2 mg kg⁻¹ ranged.

The mineral content of quinoa was collected in the outer bran layer, such as cereals (Repo Carrasco Valencia et al., 2011). The mineral content is about twice that of other grains. Growth conditions also affect the mineral content (Karyotis et al., 2003). Since the quinoa and other pseudocereals are rich in these minerals and other important minerals, the nutritional deficit can be easily closed (Alvarez-Jubete et al., 2009; Alvarez-Jubete et al., 2010).

Table 8. Amount of mineral matter in quinoa seeds (mg kg⁻¹)

| Genotypes | Mn | Mg | Cu | Fe | Zn | Pb | Cd |
|-----------|-------|---------|-------|--------|-------|-------|-------|
| 83-7 | 28.12 | 2581 | 6.47 | 78.81 | 11.28 | <R.L | <R.L |
| 85-2 | 25.66 | 2102 | 6.08 | 80.60 | 11.97 | <R.L. | <R.L. |
| 85-3 | 23.72 | 2633 | 6.58 | 85.27 | 12.98 | <R.L | <R.L |
| 86-7 | 27.12 | 1907 | 5.88 | 83.08 | 10.43 | <R.L. | <R.L. |
| 124-2 | 26.07 | 2046 | 6.11 | 67.26 | 10.07 | <R.L. | <R.L. |
| 124-5 | 25.88 | 2221 | 6.60 | 154.00 | 1.27 | <R.L | <R.L |
| 126-3 | 24.70 | 1713 | 5.34 | 107.00 | 14.19 | <R.L | <R.L |
| 127-2 | 21.86 | 1924 | 5.32 | 65.58 | 12.16 | <R.L | <R.L |
| 127-5 | 25.28 | 2049 | 6.68 | 91.04 | 11.56 | <R.L | <R.L |
| 129-1 | 28.72 | 2380 | 5.99 | 83.21 | 12.17 | <R.L | <R.L |
| 186-1 | 14.25 | 2041 | 5.00 | 68.51 | 9.07 | <R.L. | <R.L. |
| 187-3 | 22.71 | 2211 | 5.15 | 77.29 | 9.16 | <R.L | <R.L |
| 188-2 | 23.56 | 2872 | 6.35 | 80.40 | 10.28 | <R.L. | <R.L. |
| 191-2 | 45.64 | 3068 | 6.25 | 530.00 | 12.12 | <R.L | <R.L |
| 192-4 | 29.89 | 1854 | 6.09 | 179.00 | 14.28 | <R.L. | <R.L. |
| 197-1 | 31.70 | 2200 | 6.96 | 109.00 | 13.19 | <R.L. | <R.L. |
| 208 | 30.55 | 1902 | 7.49 | 94.35 | 12.87 | <R.L | <R.L |
| 2012-2 | 26.66 | 2341 | 6.66 | 92.77 | 12.22 | <R.L | <R.L |
| 215 | 28.11 | 2371 | 6.98 | 253.00 | 11.50 | <R.L | <R.L |
| 219-1 | 33.35 | 1966 | 6.25 | 84.91 | 11.37 | <R.L | <R.L |
| min | 14.25 | 1713.00 | 5.00 | 65.58 | 1.27 | | |
| max | 45.64 | 3068.00 | 7.49 | 530.00 | 14.28 | | |
| mean | 27.18 | 2219.10 | 6.21 | 123.25 | 11.21 | | |
| skewness | 1.14 | 0.96 | -0.24 | 3.38 | -2.62 | | |
| kurtosis | 4.85 | 0.53 | -0.17 | 12.41 | 9.22 | | |
| sd | 5.97 | 352.16 | 0.65 | 105.86 | 2.74 | | |
| CV | 21.98 | 15.87 | 10.40 | 85.89 | 24.48 | | |

<R.L. : Below the Reporting Limit. R.L. : Reporting Limit (0.5 mg kg⁻¹)

sd: standard deviation CV: coefficient of variation

CONCLUSIONS

In fact quinoa which dates back to ancient civilizations was re-introduced to the world, declared at 2013 as the Year of quinoa in order to achieve the next millennium development goals by the United Nations Council. The most important characteristics of quinoa are gluten-free and very high nutritional value. Quinoa is a good without gluten diet product for celiac patients.

As a result of the research, absent of cadmium and palladium elements in the mineral content are

nutritionally important. The amino acid content is similar to the literature, in particular the lysine amino acid, the need for daily lysine varies depending on age and weight. The daily requirement for children aged 2 to 12 years is specified as 23 milligrams per kilogram of body weight. In terms of vitamin C content, our samples were slightly higher than the average of the literature. Vitamin B and other parameters (moisture, protein, saponin and fat) in terms of our samples were found to coincide with the literature values.

The use of quinoa as an additional product in food products is expected to increase in our country over the years. In addition, studies on quinoa cultivation and breeding seem inevitable.

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