

ECUADORIAN QUINOA (*CHENOPODIUM QUINOA* WILLD) FATTY ACIDS PROFILE

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ABSTRACT

Objective: The aim of this study was to determine the methyl esters fatty acids (FAMES) profile of quinoa seeds (*Chenopodium quinoa* Willd) of a sample cultivated in Guaranda, Ecuador.

Methods: Quinoa oil was obtained from quinoa seeds using the Soxhlet method. FAMES identification and quantification were carried out using the gas chromatography (GC) with a mass spectrometry (MS), using the database Library NIST14.L to identify the fatty acids present in quinoa oil.

Results: Quinoa oil from Ecuador was analyzed by GC-MS, to obtain four majoritarian fatty acids, palmitic acid (10.66%), oleic acid (24.70%), linoleic acid (62.47%), and linolenic acid (2.19%). Omega 6 was the most abundant fatty acid in quinoa oil. Quinoa oil has a good proportion of oleic acid and linoleic acid.

Conclusions: Quinoa seeds present a good proportion of fatty acids. These seeds can be used in the food industry for different purposes to enjoy their fatty acids composition. Regular consumption of quinoa can improve health.

Keywords: Quinoa, *Chenopodium quinoa* Willd, Fatty acids, Methyl esters fatty acids, lipids.

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INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd) is an Andean pseudocereal plant of the *Amaranthaceae* family. Quinoa is considered one of the grains of the 21st century [1-3] for their agronomic characteristics and nutritive and biological properties. Quinoa has been cultivated and consumed for the past 5000–7000 years by the indigenous Andean region populations. The indigenous considered quinoa as the sacred “mother grain.” Quinoa seeds have been introduced as a gourmet food in international markets and their exports have experienced an increase from 5000 to 40,000 tons in the last years, increasing then production in these countries. *C. quinoa* plants are cultivated in vast areas and sustain the traditional economy of small growers who cultivate multiple varieties in these countries [4,5].

In the Andean region, the most common use of quinoa is the consumption of the seeds. Quinoa seed presents a protein content ranging from 12.5% to 16.5%, a fat content ranging from 5.5% to 8.5%, 3.0–3.8% of ash content, carbohydrate content of 60.0–74.7%, and a total crude fiber ranging 1.92–10.5%. Unsaturated fatty acids of quinoa seeds have been described by different authors with values of 23.3%, 26.0%, and 24.8% of oleic acid (omega 9); 53.1%, 50.2%, and 52.3% of linoleic acid (omega 6); and 6.2%, 4.8%, and 3.9% of linolenic acid (omega 3) [6-8]. Omega 3 and omega 6 are called “essential fatty acids” or EFAs, as they are not synthesized by the human body. They need to be included in the diet for this reason. The main saturated fatty acid is the palmitic acid with reported values ranging from 8.85%, 11.0%, and 9.0% [9-11].

Quinoa oil has a remarkable stability against oxidation due to the presence of a high content of the α -tocopherol component [12,13]. The aim of this study was to characterize the composition of fatty acids methyl esters (FAMES) present in quinoa oil samples cultivated in Ecuador using the gas chromatography mass spectrometry detector (GC-MSD).

METHODS

Oil extraction

Quinoa (*C. quinoa* Willd) was obtained from a quinoa germplasm bank at the State Bolivar University, campus Alpacaca, Guaranda, Ecuador. Quinoa oil sample was obtained using a Soxhlet apparatus for approximately 5 h with hexane as solvent, with a solid to solvent ratio of 1/7 m/v. After the extraction process, the flask contents were filtered, and the liquid fraction containing the lipid extract and solvent was poured into a 250-mL flask of a rotary film evaporator to remove the solvent. The oil was collected, evaporated under nitrogen, weighed, and stored in sealed amber glass vials at –20°C until analysis [14].

Fatty acids analysis by GC-MSD

Quinoa seeds oil fatty acid composition was analyzed by injecting fatty acid methyl esters [15,16] into an Agilent Technologies 7980A system GC (Agilent, Santa Clara, CA) equipped with a MSD 5977A GC/MSD, an auto-sampler 7693, column (60 m × 250 μ m × 0.25 μ m, Agilent 122–7062). The oven temperature ramp 2: at 200°C at 25°C/min for 10 min and ramp 3: at 250°C at 2°C/min. The injector and detector temperatures were set at 250°C. Helium was used as carrier gas at a linear flow velocity of 1.4 mL/min.

RESULTS

Quinoa seeds (*C. quinoa* Willd) were obtained of a cultivar of the faculty of agricultural sciences, natural resources, and the environment of the State Bolivar University in Guaranda, Ecuador. Quinoa seeds were collected manually by the university employees (Fig. 1).

FAMES from quinoa oil (*C. quinoa* Willd) were analyzed by GC-MS and the identification of fatty acids was made using the spectrum of a database Library NIST14.L. The chromatogram of GC presents four abundant peaks which were separated with an excellent resolution of each peak with the help of a column Agilent DB-WAX 122–7062.

These peaks presented in the chromatogram were identified using the spectrum of the library. The first peak presented a retention time of 13.976 min and was identified as C16:0, the second peak presented a retention time of 17.218 min and was identified as C18:1, the third peak presented a retention time of 18.389 min and was identified as C18:2, and finally, the fourth peak presented a retention time of 19.911 min and was identified as C18:3. The separation and definition of the four peaks were excellent in the GC chromatogram (Fig. 2).

The concentration of FAMES present in quinoa seeds was determined using the peak area ratio. Table 1 shows the percentage of main quinoa oil fatty acids. C16:0 with a value of 10.66% of palmitic acid total content, C18:1 with a value of 24.70% of oleic acid total content, C18:2 with a value of 62.47% of linoleic acid total content, and C18:3 with a value of 2.19% of linolenic acid total content. Quinoa oil from Ecuador presents a high content of unsaturated fatty acids, such as oleic acid and linoleic acid.



Fig. 1: Quinoa seeds (*Chenopodium quinoa* Willd) from Ecuador

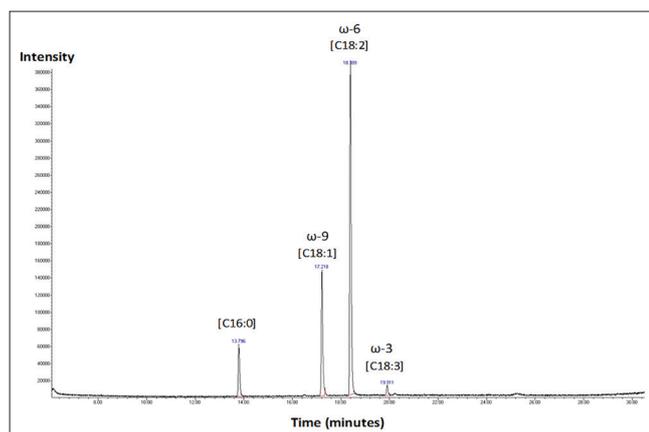


Fig. 2: Gas chromatography chromatogram of methyl esters fatty acids of quinoa oil from Ecuador

Table 1: Fatty acid composition of quinoa seeds from Ecuador by GC/MS analysis

Retentions time	FAMES	Chemical name	N° carbons	% Peak area
13.796 min	Palmitic acid	Hexadecanoic acid	C16:0	10.66±0.75
17.218 min	Oleic acid	Cis-9-octadecenoic acid	C18:1	24.70±0.34
18.389 min	Linoleic acid	9,12-octadecadienoic acid	C18:2	62.47±0.56
19.911 min	Linolenic acid	Octadeca-9,12,15 - Trienoic acid	C18:3	2.19±0.10
Saturated				10.66±0.75
Monounsaturated				24.70±0.34
Polyunsaturated				64.66±0.66

GC/MS: Gas chromatography/mass spectrometry, FAMES: Methyl esters fatty acids. Data are expressed as the mean±standard deviation (n=3)

Fig. 3a-d shows typical mass spectrum of palmitic acid, oleic acid, linoleic acid, and linolenic acid. They present typical fragmentation of ions in the mass spectrum. These mass spectrums were used to identify the structural formula and chemical name of fatty acids present in quinoa (*Chenopodium quinoa* Willd).

DISCUSSION

Quinoa is a pseudocereal with an oil content value from 1.8% to 9.5% depending of the variety of the crop. Quinoa grains have a higher content of oil than typical cereals such as maize (3–4%), white rice (0.66%), brown rice (2.92%), and wheat (1.54%) [5]. Consumption of vegetal oil is high in the world, as these oils can have a good balance of essential fatty acids “EFAs” and non-essential fatty acids “NEFAs.” Many fatty acids are synthesized by the human body, and these are known as “non-essential fatty acids” because they are not essentially needed in the diet. However, human body cannot produce EFAs, such as linoleic acid and linolenic acid, these EFAs need to be introduced in the diet [17,18]. EFAs can be grouped in two families called omega 3 (ω-3) and omega 6 (ω-6) [19]. Linoleic acid (omega 6) is the polyunsaturated fatty acid most abundant in quinoa oil in this study, the value reported was 62.47% of linoleic acid, being this value in accordance with data previously reported by different authors such as Peiretti *et al.* (2013) [20], Tang *et al.* (2015) [21], and Pelligrini *et al.* (2018) [22]. Pelligrini *et al.* (2018) reported the content of linoleic acid in six different quinoas obtained in Bolivia and Peru with values of 48.76%, 49.66%, 50.16%, 50.89%, 52.44%, and 53.94% [22]. The value reported in this study of linoleic acid is 62.47%, higher than the value reported by Pelligrini *et al.* (2018) [22]. Fat is an important component of the diet and plays a crucial role in the regulation of plasma cholesterol levels [23]. Different studies support the idea that a diet rich in vegetable oil with a high content of linoleic acid (omega 6) can help to produce a hypocholesterolemic effect. Common vegetable oils rich in linoleic acids such as corn (52.68%), sunflower (56.5%), and soybean (53.7%) have a hypocholesterolemic effect already reported in animal and human studies [24,25]. The profile of quinoa oil is similar to the profile reported for corn oil, sunflower oil, and soybean oil with a high content of polyunsaturated fatty acids, with a percentage of linoleic acid in quinoa higher than values reported in these three vegetable oils. Regular consumption of quinoa seeds in the diet can be healthy and can reduce the cardiovascular risk.

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AUTHOR CONTRIBUTIONS

Carrillo W, Altuna JL, Quinteros MF, and Morales D conceived and designed the experiments. Silva M and Alvarez M performed the gas chromatography analyses. Carrillo W wrote the paper.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

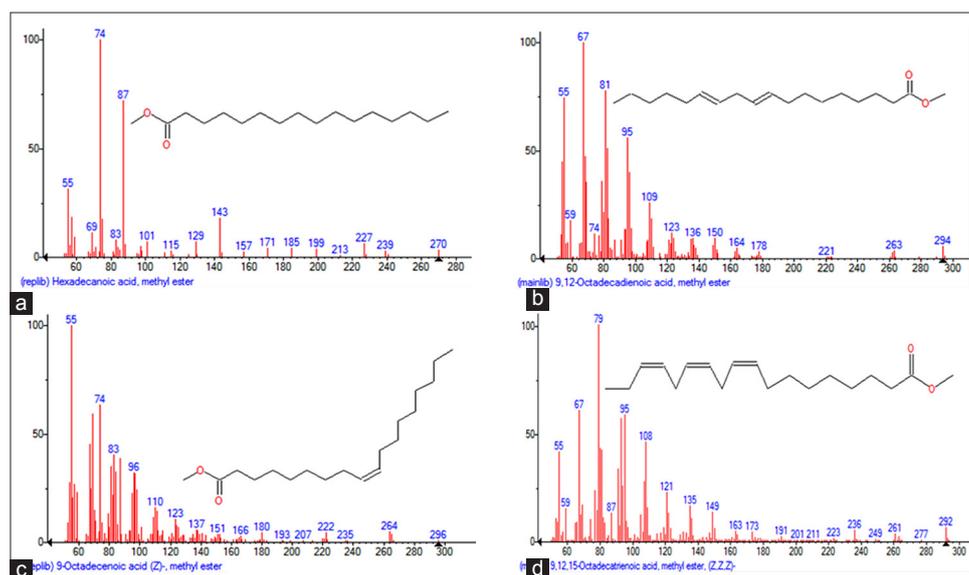


Fig. 3: (a) Mass spectrum of palmitic acid, (b) mass spectrum of oleic acid, (c) mass spectrum of linoleic acid, and (d) mass spectrum of linolenic acid

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