

IDENTIFICATION OF FATTY ACIDS IN SACHA INCHI OIL (*CURSIVE PLUKENETIA VOLUBILIS L.*) FROM ECUADOR

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ABSTRACT

Objective: The aim of this study was to identify fatty acids in a sacha inchi oil sample.

Methods: Sacha inchi oil was obtained of sacha inchi seeds using the cold pressing method. Fatty acids analysis was carried out using the gas chromatography with a mass selective detector and using the database Library NIST14.L to identify the compounds.

Results: Sacha inchi seeds have a high content of unsaturated fatty acids with 34.98% of $\omega 6$ α - Linoleic and 47.04% of $\omega 3$ α - Linolenic. Sacha inchi seeds only have 3.98% of palmitic acid.

Conclusions: Sacha inchi seed is a good source of fatty acids $\omega 3$ and $\omega 6$, being $\omega 3$ and $\omega 6$ in a good proportion. Sacha inchi oil can be used to elaborate functional foods.

Keywords: Sacha inchi, *Pluketenia volubilis*, Fatty acids, Gas chromatography - mass selective detector, Methyl ester.

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INTRODUCTION

Sacha inchi (*Pluketenia volubilis* L), also named Inca peanut, is a plant that grows in the wild being native of the rainforests in the Andean region of South America. This plant belongs to the *Euphorbiaceae* family and is composed of nineteen species [1]. It is known that sacha inchi seeds have a high content of oil (35–60 %) and proteins (27%) and contain heat-labile substances with a bitter taste [2].

Different studies have reported unsaturated fatty acids in sacha inchi seeds, being around 93% unsaturated fatty acids of the total fatty acids. In particular, high levels of essential fatty acids (EFA) were found, namely, C18:3 $\omega 3$ (α -Ln, cis, cis,cis-9,12,15-octadecatrienoic acid; α -linolenic) and C18:2 $\omega 6$ (L, cis,cis-9,12-octadecadienoic acid; α -linoleic) fatty acids, accounting approximately of 47 % and 37%, respectively, of the total fatty acids [3,4]. EFAs are intermediate metabolite in the synthesis of some many compounds in the human organism, such as prostaglandin E1 and its derivate. Several studies have reported that ω -6, and especially, ω -3 unsaturated fatty acids have beneficial effects on human health by preventing several diseases such as cancer, coronary heart disease, and hypertension [5,6]. The aim of this work was to characterize the composition of fatty acids methyl esters (FAMES) present in sacha inchi oil samples cultivated in Ecuador by gas chromatography-mass selective detector (GC-MSD). The knowledge acquired in this study will help to determine the potential of sacha inchi seed oil to be commercially exploited for industrial applications and incorporation into functional foods to help human health.

METHODS

Oil extraction

Sacha inchi was cultivated in Amazon Ecuadorian. Sacha inchi oil sample was obtained using the cold pressed method from sacha inchi seeds. Oil was then stored at $4.0 \pm 2^\circ\text{C}$. Oil extraction was conducted using a Soxhlet apparatus during 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 obtained oil was collected, evaporated under nitrogen, weighed, and stored in sealed amber glass vials at -20°C until analysis [7].

Fatty acids analysis by GC-MSD

The fatty acid composition of oil extracted from sacha inchi seeds was analyzed by injecting FAMES [8] 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 \times 250 μm \times 0.25 μm , Agilent 122-7062). The oven temperature was programmed as follows: From 80°C , ramp 1: To 100°C at $20^\circ\text{C}/\text{min}$ during 1 min; ramp 2: At 200°C at $25^\circ\text{C}/\text{min}$ during 10 min; and ramp 3: At 250°C at $2^\circ\text{C}/\text{min}$. 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

Sacha inchi fruits either in immature or mature state have a four-point, five-point, and six-point stars, respectively, with a seed inside each start point (Fig. 1a and b). It is then necessary to remove the skin of the fruit before obtaining the sacha inchi oil (Fig. 1c and d).

Sacha inchi oil sample was obtained with cold pressing method, and fatty acids were subsequently methyl esterified. Fatty acids from sacha inchi were identified using GC/MSD. The precursor ions were compared to three database Library NIST14.L. Five majority peaks were identified with their associated retention time: C16:0 with a retention time of 19.332 min; C18:0 with a retention time of 26.005 min; C18:1c with a retention time of 26.869 min; C18:2 with a retention time of 28.644 min, and finally, C18:3 with a retention time of 31.122 min (Fig. 2).

The concentration of fatty acids was calculated with a peak area percentage. FAMES were characterized as follows: C16:0 palmitic acid

with 3.98% of fatty content, C18:0 stearic acid with 3.12% of fatty content, C18:1c oleic acid with 8.58% of fatty content, C18:2 linoleic acid (LA) with 34.98% of fatty content, and finally, C18:3 linolenic acid with 47.04% of fatty content (Table 1).

When the sacha inchi fatty acid composition is compared with some common vegetable oils, it can be seen that only olive oil has a high content of mono-unsaturated fatty acids, and C18:1 named oleic acid with 77.6% of oleic acid. Sacha inchi oil has only a content of 8.58% of oleic acid. Sacha inchi has a high content of polyunsaturated fatty

Table 1: FAMES identified in sacha inchi oil sample from Ecuador by GC/MSD analysis together with their peak area ratio percentage

| Peak | Peak area ratio (%) | Carbon number: Double bound | FAMES name |
|--------|---------------------|-----------------------------|----------------|
| 19.332 | 3.98 | C16:0 | Palmitic acid |
| 26.005 | 3.12 | C18:0 | Stearic acid |
| 26.869 | 8.58 | A9 - C18:1c | Oleic acid |
| 28.644 | 34.98 | A9,12- C18:2 | Linoleic acid |
| 31.122 | 47.04 | A9,12,15- C18:3 | Linolenic acid |

GC/MSD: Gas chromatography/mass selective detector, FAMES: Fatty acids methyl esters

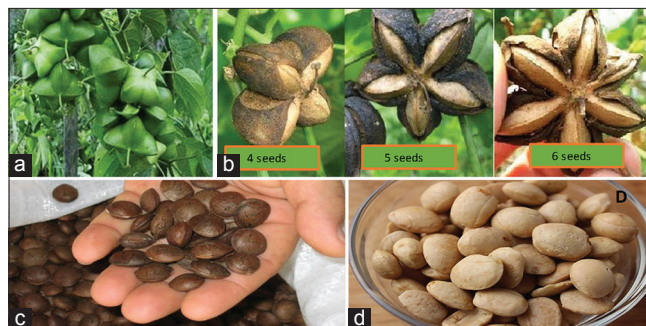


Fig. 1: (a) Sacha inchi green fruit (b) Sacha inchi seed mature (c) Sacha inchi seed mature with peel (d) Sacha inchi without peel.

acids (PUFAs). Olive oil contains few omega-6 and omega-3 fatty acids with 9.0% and 1.0%, respectively (Table 2). Oleic acid is recommended as an intake of monounsaturated fatty acids to reduce the risk of cardiovascular diseases.

On the other hand, sacha oil contains a high content of omega 6 and omega 3 fatty acids. The optimum ratio of those two fatty acids, omega 6 and omega 3 is 1:1 and 4: 1 [10]. The ratio found in sacha inchi oil of omega 6:omega 3 is 1:1.3.

Many of the chronic conditions, cardiovascular diseases, diabetes, cancer, obesity, autoimmune diseases, rheumatoid arthritis, asthma, and depression are associated with an increased production of thromboxane A2, leukotriene B4 (LTB4), interleukin (IL) -1 α , IL-6, tumor necrosis factor (TNF), and C-reactive protein. The previous molecule levels increase with increases in omega-6 fatty acid intakes and decrease with increases in omega-3 fatty acid intakes [11,12]. Sacha inchi oil contains more omega-3 in its composition. Therefore, sacha inchi can be a good candidate to prevent different diseases such as cancer, cardiovascular diseases, diabetes, and others.

DISCUSSION

Lipids are a major component of the human diet. EFAs are crucial dietary constituents for normal growth, development, and maintenance of internal homeostasis. High quantities of EFA may be found in plant seeds distributed in many regions of the world. These plants can provide oils with a high concentration of monounsaturated fatty acids that prevent cardiovascular diseases through several mechanisms [13]. The consumption of saturated fat in Ecuador is high, and the balance ω 3 and ω 6 is not correct in many processed foods. Dietary EFA includes LA, an n-6 FA, and alpha-linolenic acid (ALA), an n-3 FA. These EFA cannot be synthesized by the human body being necessary to supply them through dietary intake [14-16]. More importantly, EFA is metabolized with very long-chains (VLC) PUFAs. For instance, LA is converted to VLCPUFA arachidonic acid, and ALA is converted to both VLCPUFAs eicosapentaenoic acid and docosahexaenoic acid. Both EFA and their associated VLCPUFA metabolites are important for various body functions, including growth, immunity function, and cognitive development [17,18].

The results obtained in this study are in accordance to fatty acids levels from sacha inchi seeds reported in different studies. Fanali *et al.*, 2011, has reported 36.2% of linolenic acid (ω 6) and 46.8% of linoleic acid (ω 3) [2]. Fanali *et al.* only reported 4.0% of palmitic acid content.

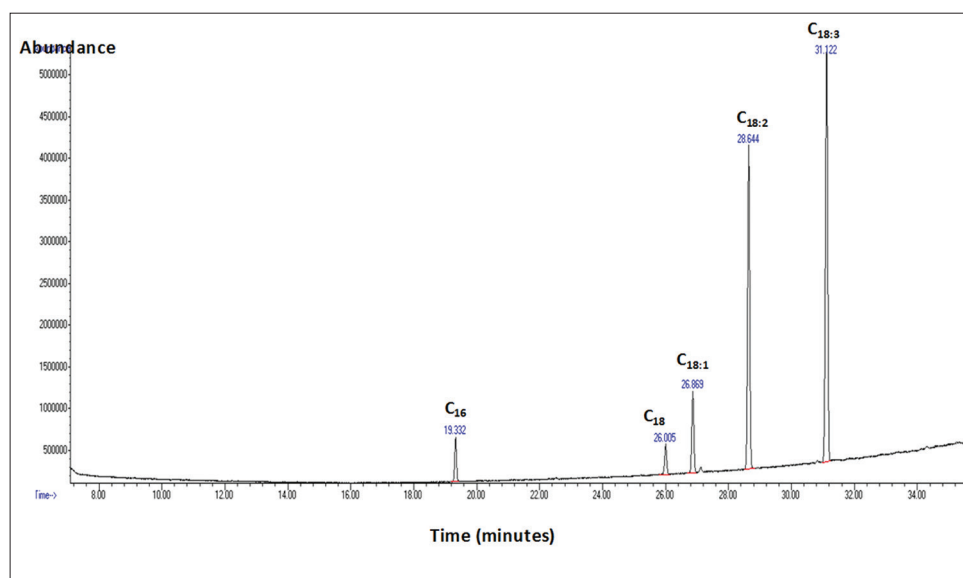


Fig. 2: Gas chromatography–mass selective detector analysis of fatty acids present in sacha inchi oil sample

Table 2: Fatty acid composition (%) of six vegetable oils

| Reference | Vegetal oil | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 |
|-----------|-----------------|-------|-------|-------|-------|-------|-------|
| [9] | Olive oil | 13.8 | 1.4 | 2.8 | 71.6 | 9.0 | 1.0 |
| [9] | Sunflower oil | 5.2 | 0.1 | 3.7 | 33.7 | 56.5 | 0.0 |
| [9] | Palm oil | 44.8 | 0.0 | 4.6 | 38.9 | 9.5 | 0.4 |
| [9] | Soybean oil | 10.1 | 0.0 | 4.3 | 22.3 | 53.7 | 8.1 |
| [9] | Corn oil | 11.6 | 0.0 | 2.5 | 38.7 | 44.7 | 1.4 |
| [9] | Sacha inchi oil | 3.98 | 0.0 | 3.12 | 8.58 | 34.98 | 47.04 |

Gutiérrez *et al.*, 2011, reported 33.4% of linolenic acid (ω 6), 50.8% of linoleic acid (ω 3), and 4.4% of palmitic acid [19]. Bondioli and Bella, 2006, reported 33.67% of linolenic acid (ω 6), 50.73% of linoleic acid (ω 3), and 3.79% of palmitic acid [20]. Sacha inchi oil can be a good alternative in Ecuador to be used in the food industry due to its high nutritional quality.

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AUTHOR CONTRIBUTIONS

Quinteros MF, Carpio C, Morales D, Vasquez G and Carrillo W conceived and designed the experiments. Silva M and Alvarez M performed the gas chromatography analyses. Carrillo W wrote the paper.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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