

Composition analysis of Indonesian sacha inchi (*Plukenetia volubilis* L.) oil and potential for food nutrition

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Abstract. Sacha Saha inchi (*Plukenetia volubilis* L.), also known as "Inca bean", is a highly nutritious plant native to the Amazon rainforest and now also cultivated in Indonesia. Many people do not know the benefits of sacha inchi, especially when consumed. The purpose of this study was to evaluate the nutritional content, safety for human consumption, and benefits for public health. The methodology used was to process the seeds into oil and run various tests at Saraswanti Indo Genetech Laboratory. The results showed that Sacha inchi oil is rich in essential polyunsaturated fatty acids (ω -3 and ω -6), especially linoleic and α -linolenic acids, which are 80-90% components of the oil. Despite the lack of vitamin A, sodium, and free sugars, the oil has high levels of vitamin E (129.11 mg/100 g). It is significant that no harmful heavy metals such as cadmium, arsenic, mercury, tin, lead, or lead were found, and microbiological test results indicate that the oil is safe. According to this study, Sacha inchi oil, with its high nutritional value and safety, is a valuable source of essential fatty acids and antioxidants. According to Sustainable Development Goal 3 for good health and well-being, this oil supports health promotion.

1 Introduction

Sacha inchi (*Plukenetia volubilis* L.), also known as the "Inca peanut", "Wild peanut", "Mountain peanut", or "Inca inchi", is a plant belonging to the *Euphorbiaceae* family and grows at altitudes between 200 ~ 1,500 m in the Amazonian forest. Inchi sacha bean seeds can be seen in Figure 1. Sacha Inchi (*Plukenetia Volubilis*) is native to the Amazon forest in South America. Although Sacha Inchi is native to the Amazon, it can also grow in Indonesia. There are several factors that make the sacha inchi plant able to grow in the Indonesian region. Even though there are significant differences between the Amazon and Indonesian regions, there are some similarities between the two. Indonesia and the Amazon have a warm

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and humid tropical climate. Sacha inchi can grow well in tropical climates that have high temperatures and sufficient rainfall. The similarity of soil conditions between the two also supports the good growth of sacha inchi plants. Currently, this plant is widely cultivated in Peru and Southern Colombia for its great potential as an economic crop [1]. Sacha inchi (*Plukenetia volubilis* L.) is a perennial oilseed plant that belongs to the Euphorbiaceae family [2]. The lenticular-shaped seeds of the sacha inchi plant are high in oil and protein. Representations of the plant and its fruits have been found in Incan tombs, indicating that it was farmed by both the pre-Incans and Incans [3].



Fig. 1. Sacha Inchi Seed

Its seeds contain high levels of oil (30%–60%), protein (25%–30%), minerals, vitamin E, and phenolic compounds [4]. The distinctiveness of sacha inchi is that it contains 93% fatty acids, the majority of which are essential oils that are beneficial to health [5]. Essential polyunsaturated fatty acids (PUFAs), such as α -linolenic acid (ω -3) and linoleic acid (ω -6), are beneficial nutrition and health components, with widespread applications in pharmaceutical and supplementary food industries [6]. Bioactive substances found in sacha inchi are good for your health. Commercial sacha inchi oil is categorized as virgin and extra virgin oil. It shouldn't be heated because of its limited oxidative stability [7].

The growth of Sacha Inchi beans in Indonesia is highly advantageous due to their competitiveness in terms of health functions. However, intensive cultivation methods and the creation of sacha Inchi derivative products are needed to boost the output and high quality of sacha Inchi oil. Sacha inchi seeds have a high level of unsaturated fatty acid content. The oil that is extracted from sacha inchi seeds has numerous health benefits, including lowering blood pressure and cholesterol, reducing uric acid, increasing intellect, decreasing the danger of heart palpitations and strokes, decreasing tumor activity, reducing hip arthritis, enhancing cataract vision, and lessening tingling. α -linolenic acid (ALA), an omega-3 fatty acid, is very high in Sacha inchi nut oil, which has the highest proportion of vegetable oil (35.2–50.8%). Sacha inchi beans have a high protein content and all essential amino acids, and the amount recommended by the World Health Organization for adults to eat are not bad for them.

Given the benefits to human health attributed to the consumption of ω -3 fatty acids, Peru is currently planning to expand the use of food sources containing such fatty acids, supporting their dietary intake through strategies such as feeding guinea pigs, poultry and chickens with a combination of sacha inchi oil and fish, enriching their meat with these lipids [8]. Sacha inchi seed oil is frequently utilized in the food sector as a fortifier or food substitute. Sacha inchi seed oil can be used to substitute chicken fat in chicken sausage, hog fat in pate, and cocoa butter in dark chocolate [9]. Because of these benefits, sacha inchi seed oil has currently gained considerable interest as a crucial ingredient for cosmetic, nutraceutical, and pharmaceutical applications [10]. Sacha inchi has a high nutritional content hence, Sacha inchi is a promising source of oil [4].

Notably, sacha inchi oil is an excellent source of PUFAs, such as linoleic acid and α -linolenic acid, which account for 80%–90% of total oil content [11]. The purpose of this study is to determine the content of sacha inchi oil taken from sacha inchi bean seeds grown in West Java, Indonesia, which is good for food security. Given the lack of literature regarding the content of sacha inchi originating from Indonesia. This is very important

because the soil type and other factors in the growth of sacha inchi plants can be very different between cultivation in Indonesia (West Java) and outside Indonesia. Sustainable Development Goal (SDG) 3 is "Good Health and Well-being". Sacha inchi oil, extracted from the seeds of the sacha inchi plant (*Plukenetia Volubilis L.*), can contribute to the achievement of SDG 3 as it has significant health benefits. Sacha inchi oil provides essential nutrients and health benefits that can help individuals maintain good health, which aligns with SDG 3's goal of improving global health and well-being.

2 Material and Methods

The sacha inchi nuts used come from agricultural cultivation in West Java which are then processed into oil and tested through a partnership with CV Innovation Anak Negeri. Sacha inchi oil content was analysed at the Saraswanti Indo Genetech Laboratory (SIG) and collaborated with CV Inovasi Anak Negeri and obtained the data as described. Saraswanti Indo Genetech SIG, has been tested for validity. PT Saraswanti Indo Genetech or SIG (registration no. LP-184-IDN) is a testing laboratory located in Bogor - Indonesia and became the first laboratory in Indonesia to be accredited ISO/IEC 17025 by the National Accreditation Committee (KAN) for the scope of GMO (Genetically Modified Organism). This sacha inchi content analysis is carried out based on the Indonesian national standard (Table 1).

Table 1. Sacha Inchi Oil Composition Analysis Method

Parameter	Method
Vitamin A (Retinol)	18-5-1/MU/SMM-SIG (HPLC-PDA)
Vitamin E (Alfa Tocopherol)	
Total Sugar	18-8-8/MU/SMM-SIG (Luff Schrool)
Carbohydrate (By Difference)	18-8-9/MU/SMM-SIG (perhitungan)
Protein content	18-8-31/MU/SMM-SIG (Titrimetri)
Free Fatty Acids	18-11-17/MU/SMM-SIG (Titrimetri)
Arsenic (As)	18-13-14/MU/SMM-SIG (ICP MS)
Staphylococcus Aureus	ISO 6888-1:1999/Amd 2: 2018
Yeast molds	SNI ISO 21527-2 : 2012
Sodium (Na)	
Cadmium (Cd)	18-13-8/MU/SMM-SIG (ICP OES)
Merkury(Hg)	
Lead (Pb)	
Tin (Sn)	
Total Plate Count (ALT)	SNI ISO 4833-1 : 2015
Escherichia Coli	SNI ISO 7251 : 2012
Enterobacteriaceae	SNI ISO 21528-2 : 2017
Salmonella sp.	ISO 6579-1:2017/Amd 1:2020
C 18:1 W9C (C-Oleic Acid)	18-6-1/MU/SMM-SIG (GC-FID)
C 18:2 W6 (Linoleic Acid/W6)	
C 18:3 W3 (Linolenic Acid/W3)	
Saturated Fat	
Unsaturated Fats	
Polyunsaturated Fats	
Monounsaturated Fat	
Total Fat Content	18-8-19/MU/SMM-SIG
Total Energy	Calculation
Energy from Fat	

3 Results and Discussion

Sacha inchi is a crop that is starting to be cultivated in Indonesia. Given its rich and diverse nutritional content, Sacha Inchi may serve as a solution for food security, according to this study. Sacha Inchi oil is known to have many health benefits, including its high content of essential fatty acids and antioxidants. A recent study found that Sacha Inchi oil contains a good range of nutrients to fulfil people's nutritional needs. We will discuss Sacha Inchi's nutrition and its benefits for food security in this discussion. These analytical results include a number of ingredients that can be divided into sections, such as vitamins, minerals, and other nutritional elements. Table 2 shows the important parameters measured, the units used, the analysis results, and the detection limits for each parameter, and the following is the vitamin composition of Sacha Inchi based on the analysis results.

Table 2. Vitamin Composition of Sacha Inchi

No	Parameter	Unit	Result	Limit of Detection
1.	Vitamin A (Retinol)	mcg / 100 g	Not detected	37.00
2.	Vitamin E (Alpa Tocopherol)	mg/100 g	129.11	-
3.	Sodium (Na)	mg / 100 g	Not detected	0.1
4.	Total Sugar	%	Not detected	0.28
5.	Carbohydrate (By Difference)	%	0	-
6.	Protein content	%	<0.04	-

Sacha Inchi seeds contain 35–60% edible oil (by dry weight)—a content comparable to that of sunflower seeds and peanuts—as well as being high in protein (approximately 27% or more by dry weight) and rich in vitamins E [12]. No free sugars were detected in the sacha inchi because recent data also show that free sugars have an impact on blood pressure and serum lipids and that limiting free sugar intake reduces risk factors for cardiovascular disease [13]. The table also provides the results of carbohydrate analysis in sacha inchi. Carbohydrates play an important function in the human body. Carbohydrates provide energy, aid in insulin and blood sugar metabolism, play a role in triglyceride and cholesterol metabolism, and aid in fermentation [14]. No carbohydrate was detected in sacha inchi oil, indicating that if sacha inchi oil is consumed, it cannot provide benefits such as carbohydrates. From the table information, it can be concluded that the nutritional content of sacha inchi per 100 grams is high in vitamin E (129.11 mg), does not contain vitamin A, sodium (Na), or sugar and has a very low protein content (<0.04%). The carbohydrate content is also very low (0%). Sacha inchi, which is high in vitamin E, can help protect the body's cells from oxidative damage, which can contribute to the prevention of chronic diseases such as cancer. This aligns with efforts to achieve SDG goal 3 for improved global health and well-being.

To ensure the safe consumption of Sacha Inchi, a heavy metal content analysis was conducted. The results can be seen in Table 3. This analysis aims to ensure the safe consumption of Sacha Inchi by measuring the content of potentially harmful heavy metals. The parameters measured include arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), and tin (Sn), with the analysis results and detection limits listed in the table.

Table 3. Heavy Metals Composition in Sacha Inchi Oil

No	Parameter	Unit	Result	Limit of Detection
1.	Arsenic (As)	mg/kg	Not detected	0.0003
2.	Cadmium (Cd)	mg/kg	Not detected	0.00011
3.	Mercury (Hg)	mg/kg	Not detected	0.004
4.	Lead (Pb)	mg/kg	Not detected	0.009
5.	Tin (Sn)	mg/kg	Not detected	0.45

After testing the metal content of sacha inchi oil, it was found that arsenic, cadmium, mercury, lead and tin were not detected in sacha inchi oil. Many of these vital metals, such as cobalt, copper, iron, chromium, manganese, cadmium, molybdenum, nickel, selenium, and metallic elements, are essential nutrients that are necessary for a variety of physiological and organic chemistry processes in the body. If not consumed at sufficient levels, they can cause deficiency diseases or syndromes; however, at higher concentrations, they can cause acute and/or chronic toxicity. Due to their extreme toxicity, Arsenic, Chromium, Cadmium, mercury and lead are among the priority metals of public health concern. These gold-bearing portions are considered broad toxins that can affect many organs even at modest doses [15].

The objective of the fat composition analysis of Sacha Inchi oil was to identify the different types of fatty acids contained, as well as the contribution of total fat to energy value, as shown in Table 4. The results of this analysis provide a comprehensive overview of the fat profile of Sacha Inchi oil, including total fat content, total energy and total fat, free fatty acids, oleic acid (C-Oleic Acid), linoleic acid ($\omega 6$), linolenic acid ($\omega 3$), and saturated fat, unsaturated fat, polyunsaturated fat, and monounsaturated fat.

Table 4. Fatty Acid and Fat Content in Sacha Inchi Oil

No	Parameter	Unit	Result
1.	Free Fatty Acids	%	1.04
2.	C 18:1 $\omega 9$ C (C-Oleic Acid)	%	10.62
3.	C 18:2 $\omega 6$ (Linoleic Acid/ $\omega 6$)	%	42.01
4.	C 18:3 $\omega 3$ (Linolenic Acid/ $\omega 3$)	%	38.56
5.	Saturated Fat	%	8.20
6.	Unsaturated Fats	%	91.7
7.	Polyunsaturated Fats	%	80.81
8.	Monounsaturated Fat	%	10.89
9.	Total Fat Content	%	99.90
10.	Total Energy	Kcal/100 g	899.10
11.	Energy from Fat	Kcal/100 g	899.10

Essential polyunsaturated fatty acids (PUFAs) are commonly used to reduce heart risks, prevent cancer and cardiovascular diseases, and increase high-density lipoprotein blood quantities [16]. In vitro, PUFAs have been shown to have anti-inflammatory and immunomodulating properties [17]. From these data, it can be concluded that sacha inchi has a high-fat content, especially in the form of unsaturated fats, including mono-unsaturated fats (oleic acid) and polyunsaturated fats (linoleic acid and linolenic acid). Omega-3 and omega-6 fatty acids which are unsaturated fats have important benefits for immunity, heart health and brain function. Sacha inchi also contains low amounts of saturated fat and free fat, making it a healthy source of fat that supports health promotion and lifestyle achievement in line with SDG 3 goals.

Microbiological tests on the content of Sacha Inchi oil were conducted to ensure its quality and safety. The results of these tests are shown in Table 3.4. Plate Total Count (ALT), Escherichia Coli, Enterobacteriaceae, Salmonella sp. and Staphylococcus Aureus were some of the parameters tested.

Table 5. Sacha Inchi Oil Content by Microbiological Test

No	Parameter	Unit	Result
1.	Total Plate Count (ALT)	colony g	1.2×10^3
2.	Escherichia Coli	MPN g	0
3.	Enterobacteriaceae	colony g	<10
4.	Salmonella sp.	/ 25 g	Negative
5.	Staphylococcus Aureus	colony / g	<10

A total plate count is a measurement of the biological activity of bacteria, fungi, and yeast. In sacha inchi oil, there was a total plate count of 1200 colony grams [18]. This is very good because *Escherichia coli* is the most common cause of bloodstream infections and urinary tract infections (UTIs) among gram-negative bacteria (GNB) [19]. *Salmonella* (of the family Enterobacteriaceae) is a genus of rod-shaped (bacillus) gram-negative bacteria that is a big problem for global public health because it causes much morbidity and consequently has a big impact on the economy [20]. It is clear that these dangerous germs have an undetected presence. A Gram-positive bacterium known as *Staphylococcus aureus* is both a pathogen and a commensal microorganism in humans [21].

Less than 10 colony g of Enterobacteriaceae have been found in sacha inchi oil, indicating that the food is safe to eat. The majority of severe and potentially fatal infections are caused by Enterobacteriaceae, and these germs' resistance to several antibiotics is becoming an international public health concern [22]. Based on the data from the table, sacha inchi meets the microbiological safety standards set; the results obtained do not detect *Escherichia coli*, *salmonella* sp, and low bacterial colony counts for total plate count, enterobacteria and *Staphylococcus aureus*. Therefore, sacha inchi is safe for consumption and in accordance with the achievement of SDG 3 by giving people access to quality food and of course safe for consumption.

Table 6. Sacha Inchi Oil Content by Number Index

No	Parameter	Unit	Result
1.	Viscosity	cP	67.75
2.	Density	g/mL	0.9284
3.	Acid Numbers	mg KOH / g fat	2.07
4.	Iodine number	Wijjs	176.55
5.	Saponification Numbers	mg KOH / g	191.09
6.	Peroxide Numbers	mEq O ₂ /kg	5.6270
7.	Index of Bias	-	1.4803
8.	Energy from Fat	Kcal/100 g	899.10
9.	Ash Content	%	<0.02

Sacha inchi oil had slightly higher densities (0.920–0.930 g/cm³ at 25°C) than corn oil, cottonseed oil and soybean oil. The refractive index of sacha inchi oil (1.475) appeared to be rather similar to that of olive oil (1.467), soybean oil (1.473), sunflower oil (1.473), corn oil (1.473) and cottonseed oil (1.468) (Wang et al., 2018). The ash content or ash yield of biomass is the measured quantity of the incombustible inorganic residue resulting from the complete combustion of biomass, mainly at 500–600 C under laboratory conditions [9]. Therefore, an accurate and reliable measurement of ash content is critical in documenting quality of a biomass, whether it is a food, feed, industrial material, or renewable fuel [23]. Raw materials with a high iodine number tend to be less stable and more easily oxidized due to their high level of unsaturation [24]. Sacha inchi oil has a viscosity of 67.75 cP. High viscosity means that the distribution coefficient is slower, and the oil mass gets heavier at the same volume condition [25]. The amount of potassium hydroxide (KOH) in milligrams needed to saponify one gram of fat is known as the saponification number, or value. Sacha Inchi oil has a saponification value of 191.09, which means that the average fatty acid chain is longer the lower the saponification value [26].

Sacha inchi has a peroxide number of 5.5270 mEq O₂/kg so it is not included in the rancid oil category because the oil samples having the peroxide value more than 10 meq / O₂ kg is considered to be rancid and has various health hazards [27]. The acid number per gram of fat is 2.07 mg KOH. The mass of potassium hydroxide (KOH) in milligrams needed to neutralize one gram of a chemical substance is known as the acid value, also known as the neutralization number, acid number, or acidity. The number of carboxylic acid groups in a chemical

compound, such as a fatty acid, or in a mixture of compounds is known as the acid number [28]. The table provides information on the physicochemical parameters of sacha inchi, including viscosity, density, acid number, iodine number, saponificant number, peroxide number, refractive index, energy from fat and ash content. These data are important as they provide information on the chemical and physical properties of sacha inchi, which are important for understanding the potential and quality of its use in the health sector to promote health improvement.

Based on research by [5] states that the content of sacha inchi oil includes 93% essential unsaturated fatty acids, with omega 3 of 50.5% and omega 6 of 34.1%. Sacha inchi oil also contains omega 9, palmitic, stearic acid, phenyl alcohol, flavonoids, and sterols. Tocopherol, which is an antioxidant, is present in high amounts in sacha inchi oil. In addition, sacha inchi oil also contains bioactive compounds that are beneficial to health. Sacha inchi oil is classified as extra virgin and virgin oil and has low oxidative stability, so it should not be consumed hot. While the results of our study state that sacha inchi contains fat (30%-60%), protein (25%-30%), minerals, vitamin E, and phenol compounds. Sacha inchi fat consists of 77.5-84.4% polyunsaturated fatty acids (PUFA), which consist of 35.2-50.8% α -linolenic acid (ALA) and 33.4-41.0% linoleic acid. Sacha inchi also contains 8.4-13.2% monounsaturated fatty acids (MUFA) and 6.8-9.1% saturated fatty acids (SFA). These two studies show the health benefits of Sacha Inchi oil from slightly different angles. The study by [5] emphasizes the high content of essential fatty acids and bioactive compounds in Sacha Inchi oil, while our study provides a more detailed description of the fat composition as well as information on the content of proteins, minerals, and phenol compounds in Sacha Inchi oil.

4 Conclusion

The oil that is extracted from sacha inchi seeds has a rich nutritional profile that includes significant levels of protein, edible oil, and important vitamins A and E. Although the lack of carbs in sacha inchi oil implies that it might not aid in the provision of energy through this macronutrient, the oil's abundance in polyunsaturated fatty acids highlights its potential health advantages. The oil's stability and quality are shown by its physical and chemical characteristics, such as density, saponification value, and refractive index, while microbiological investigations verify its safety. Because of its adaptability and high nutritional content, sacha inchi oil is a prospective addition to food and cooking applications. Recommendations for further research on the quality of Indonesian Sacha Inchi oil content are to conduct further research on the oxidative stability of Sacha Inchi oil using various storage and preservation methods. This may provide important insights on how to extend the shelf life of this product, especially since the oxidative stability of this oil is low. conduct research on the incorporation of Sacha Inchi oil into various useful food products, such as dietary supplements, baby food, or speciality medical foods, to evaluate the health benefits and market prospects.

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