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Effect of adding sacha inchi (*Plukenetia volubilis* L.) seeds to a prototype of convenience food draft, on the nutritional composition and sensory acceptance

Edwin Darío Betancur-Hoyos[1]*, Luz Amparo Urango-Marchena[2] and Luis Fernando Restrepo-Betancur[3]

[1]Escuela de Nutrición y dietética, Universidad de Antioquia. Carrera 75 Nº 65-87, Bloque 44 Ciudadela Robledo, Medellin, Colombia.
[2]Docente Escuela de Nutrición y Dietética, Universidad de Antioquia. Grupo ICAS. Carrera 75 Nº 65-87, Bloque 44 Ciudadela Robledo, Medellín, Colombia.
[3]Docente Facultad de Ciencias Agrarias. Universidad de Antioquia. Grupo Giser. Carrera 75 Nº 65-87, Bloque 44 Ciudadela Robledo, Medellín, Colombia.

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The polyunsaturated fatty acids of Sacha Inchi seeds are important in the development of food products with healthy and nourishing properties. The aim of this study was to evaluate the effect of Sacha Inchi (*Plukenetia volubilis L*) on a prototype convenience food. The nutritional composition and sensory acceptance was evaluated using a completely randomized experimental design. Fixed effect-balanced factorial multiple correspondence analyses were used for the different treatments. Four formulations were developed for the prototype type setting (F0, F5, F7.5 and F10) using Sacha Inchi almonds characterized according to their nutritional composition. The fatty acid composition of the total lipids of the seed was determined by gas chromatography. In the food draft type, sensory parameters such as color, odor, flavor and texture in all treatments were evaluated. The results obtained showed a content polyunsaturated fatty acids of 33.74% in the seed. In addition, the acceptance of sensory parameters evaluated by consumers in the draft prototype was greater than 80%. It was observed that lipid content increased up to 3 times and the content of polyunsaturated fatty acids, 4 times in the treatment of F10 with regard to white F0. About 10% almond Sacha Inchi can be effectively incorporated into draft products with suitable timing sensory characteristics and nutritional value, thus, allowing the foods declared under the Colombian law as a high and good source of omega 3.

Key words: Prototype, *Plukenetia volubilis* L, polyunsaturated fatty acids, draft.

INTRODUCTION

Sacha inchi plant is a plant native to the Amazon región, it is known by various names, such as “Gold Inka”, “Inca Inchi” o “Inca peanut”, is a plant of the Euphorbiaceous family and volubilis species is a climbing plant, semi-ligneous, fruits in capsule, with 4 seeds oval and dark brown (Manco 2006). The flour and oil from the seeds are commonly used by the Peruvian natives. The seeds contain approximately, on average, 48% oil and 27% proteins that are rich in essential amino acids (Maurer et al., 2012). The nutritional composition of sacha inchi is

characterized by high levels of essential fatty omega 3 (ω-3) and omega 6 (ω-6),), which have been documented to have effects on the human health by preventing various diseases like arthritis , coronary heart disease , diabetes, hypertension , attention deficit hyperactivity, and inflammatory skin diseases.(Hanssen and Schmitz-Hübsch, 2011) (Gogus and Smith, 2010), according to this context , the use of almonds extracted from the seeds of Sacha inchi has a high potential for nutraceuticals industry (Guillén et al., 2003).

The development, design and innovation of products to help the world population, have spurred the search for alternatives to the production of food with functional properties; hence, the seeds of Sacha inchi *(Plukenetia volubilis* L.) was proposed for use in the oil and cosmetic industries, with little use in the manufacture of food products for human consumption (Guillén et al., 2003), several authors have reported the development of foods with added Sacha inchi as sausage type Frankfurt (Romo, 2015), beverage with cake Sacha inchi (Cárdenas, 2015) and energy bar with addition of seed. (Baéz and Borja, 2013 a). The United Nations Organization for Food and Agriculture (FAO, 2008) has recommended increasing the intake of fatty acids (ω-3) to the general population, and to comply with this recommendation, they enriched a variety of food products such as eggs, yogurt, milk, and spreadable foods (Riediger et al., 2009). Developed countries currently have among other challenges for the populations, the offer to consumers who have little time to prepare their food, through options of healthy processed foods ready for consumption, known as food ready to-eat or convenience (Dutcosky et al., 2006), that are oriented to the trend of snack foods; that are characterized by having a higher energy density and sodium, with high content of carbohydrates and significant sensory characteristics such as taste and texture.

On the basis of the interest of consumers to purchase foods that have a positive impact on human health, in Colombia, they are developing foods from new sources of nutrients with foods considered promising, low production costs and cultivated with few agronomic requirements (Peralta, 2010), This is the case of the seed of Sacha inchi from the biodiversity of Latin American countries, with high nutritional potential (Guillén et al., 2003). The aim of this study is to evaluate the effect of adding Sacha inchi seeds, to a prototype of convenience food draft, on the nutritional composition and sensory acceptance.

MATERIALS AND METHODS

3 kg of seeds were collected of *P. volubilis* L. sedes from the Municipality of Santo Domingo, Antioquia-Colombia, with characteristics of healthy seed grain without broken bark or exposed almond, was used.

Physico-chemical analysis

The following parameters were analyzed: Protein by AOAC No. 954.01, moisture by GTC 1.14, ashes by AOAC No. 923.03, total fat by GTC 6.1. 996.06 total carbohydrates calculated on the basis of its components by difference.

Fatty acid profile of sacha inchi seed

Lipid phase extraction of the Sacha Inchi seed was performed and 0.5 mL of hexane was added to 1.5 mL of the Sacha Inchi extract which was derivatized with 5 mL of boron trifluoride BF3 methylation (Ackman, 1998) in methanol for the trans methylation fatty acids present. The fatty acids were determined using a gas chromatograph (Agilent 7890 B with detector FID, with auto sampler 7963 A), equipped with a split injector relation: 100:1, with a capillary column of silica TRCN-100 (60.0 m x 0.25 mm i.d x 0.20 µm) (brand TEKNOKROMA) and a flame ionization detector; The gases used was Hydrogen (H_2) and air, gas makeup: Nitrogen (N_2). The volume of injection was 1.0 µL. The injector and detector temperatures were 250 and 260°C, respectively. Initial oven temperature of 100°C was gradually increased to 145°C at 8°C/min. Helium was used as carrier gas at a linear flow of about 1.5 ml/min. The retention times and peak areas were processed using OpenLab CDS ChemStation software. For identification of fatty acid retention time and peak areas of the samples with mixture of reference standards, Food Industry FAME mix (37 parts) Mark RESTEK components, diluted in 30 mg/ml of dichloromethane. Fatty acids were quantified through a percentage of the peaks with the total area. All reagents used in the extractions were reagent grade and in the chromatography separation, HPLC grade.

Prototype development of the draft food type

Sacha inchi seeds were hulled for the almond and pre-toasted in a convection oven (brand: UNOX reference BakerTop XBC615), between 80 ± 5°C for 15 min. Then the seeds were finely cut to a particle size between 1.0 and 2.0 mm. The protocol for the development of the prototype food was adapted and standardized in laboratory conditions accordingly (Marpalle et al., 2014). Ingredients such as whole wheat flour, water, brown sugar, instant dry yeast, dietary salt all trademark, obtained from local supermarkets were used.

The ingredients were weighed separately, mixed in a blender (Mixer Spartan reference mark SP500, engine 750W, 110 V / 60Hz, 10vel) for 20 min in a speed of 5 rpm to form a gluten network, and then the Sacha inchi pre-toasted almonds were added at different concentrations and chopped, with respect to whole wheat flour (F5): 5%; (F7.5): 7.5% and (F10) 10%, mixing them for 2 min, except (F0): 0% (white) that had no addition of almonds (Table 1). The mass is left to rest for 40 min and then cut into squares of 2 x 2 cm. It was taken to camera fermentation (brand Javar) with a temperature of 35 ± 5°C and relative humidity of 80% for 1 h to double its size. Subsequently, they were baked at 165°C for 11 min, and finally achieved a draft at 90°C for 30 min (Figure 1). They

*Corresponding author. E-mail: edwinbeta@gmail.com.

Table 1. Ingredients for treatment of the prototype food.

Ingredients	F0	F5	F7.5	F10
Whole wheat flour (g)	100	100	100	100
Sacha inchi (pieces) (g)	0	5	7.5	10
Brown Sugar (g)	6	6	6	6
Instant dry yeast (g)	1.7	1.7	1.7	1.7
Dietary salt (g)	0.3	0.3	0.3	0.3
Water (ml)	65	65	65	65

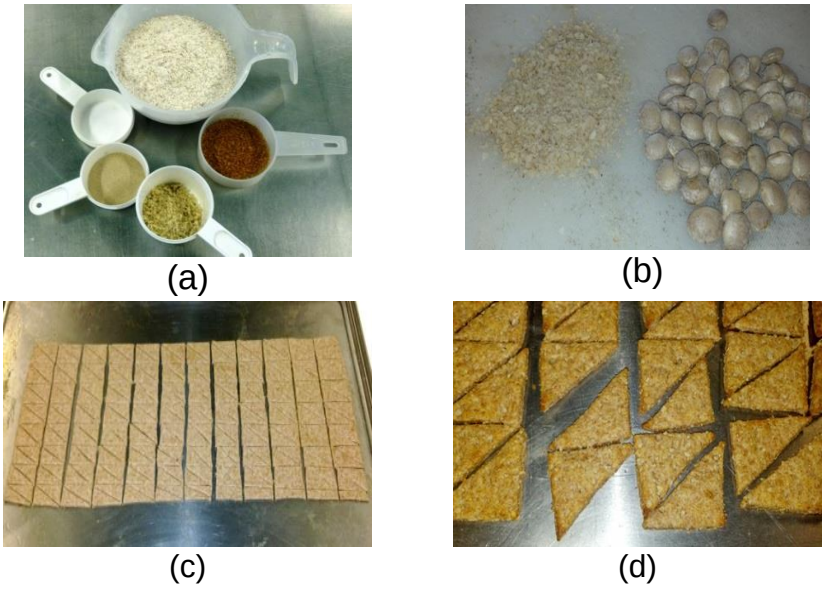

Figure 1. Preparation of food draft prototype. (a) Enlistment (b) Sacha inchi Pieces (c) Rolling and cutting (d) Baked snack.

were cooled on trays for packaging in foil bags, to avoid hygroscopicity and oxidation of fats in the prototype food type setting (Marpalle et al., 2014).

Analysis of the chemical constituent of the prototype food

The following parameters were analyzed: fat by Soxhlet extraction method (NTC 668), moisture by thermo gravimetric method (based on ISO 6496) and protein by Kjeldahl (NTC 4657), the latter worked with a factor of (N × 6.25), the ash by direct incineration method (AOAC 942.05).

Fatty acid profile of the prototype food

They weighed between 1.0 to 2.0 g of the prototype food milled and homogenized. Then hydrolysis of the fat from the seed was conducted with 1,000 g of Celite, 100 mg of BHT and 120 ml of 4N HCl, stirring for 2 min. 2.0 ml Glyceryltriundecanoate of the internal standard (C11: 0) was added to 5.0 mg/ml to start the hydrolysis unit (FOSS reference mark 1047) for 1 h; rinsed and the supernatant was filtered. Subsequently, it was taken to the extraction unit for removal of Soxtec fat (Brand: Reference FOSS 1047) with 50 mL of hexane. The extracted fat was cooled in a desiccator and then the fatty acid profile was analyzed by gas chromatography with flame ionization detector (GC-FID).

Sensory analysis of the prototype food

Affective method was applied, using a binomial hedonic scale acceptance test (Sancho et al., 2002), evaluating the attributes of color, taste, smell and texture, to analyze the differences between them.

The samples of the prototype food type setting (F0, F5; F7.5; F10) were evaluated by 120 non-regular users of the product of both sexes, in age ranges of 15 to 25; 26 to 35; 36 to 45; 45 to 55, and greater than 55 years, and they were classified into 4 groups chosen at random, each consisting of 30 people who completed the survey type format after consuming the product. The samples were presented in thermo forming packaging (reference AL69P). Statistical analysis entailed applying the multivariate technique called factorial analysis of multiple correspondence (ASM) with additional variable (treatment) using the SPAD version 3.5 program. This analysis allows determining the similarities or dissimilarities between individuals concerning the attributes evaluated in sensory analysis.

Table 2. Nutritional composition of sacha inchi seed *(P. volubilis L).*

Parameter	*Mean ± SD
Humidity (%)	4.7 ± 0.04
Total mineral (%)	2.7 ± 0.04
Total fat (%)	42.3 ± 0.02
Total Protein (%)	25.6 ±1.27
Total carbohydrates (%)	24.5
Total calorie (Kcal / 100 g	481.5

* Dry basis amounts expressed in percentage (%).

Table 3. Fatty acid profile of sacha inchi seed (*P. volubilis* L).

Fatty acid profile	Fatty acids	*Percentage ± De
	Myristic acid	0.02 ± 0.0007
	Palmitic acid	1.85 ± 0.001
Saturated fat	Heptadecanoic acid	0.04 ±0.0003
	Stearic acid	1.26 ±0.002
	Behenic acid	0.01 ±0.0001
	C16: 1 (palmitoleic acid)	0.03 ± 0.001
Monounsaturated fat	C18: 1n9c (oleic acid)	3.4 ± 0.009
	C20: 1n9 (cis-11-eicosenoic acid)	0.17 ±0.001
	C18: 2n6c (linoleic acid)	13.7 ± 0.05
Polyunsaturated fat	C18: 3n3 (a-linolenic acid)	19.9 ± 0.06
	Cis-11,14-eicosadienoico	0.02 ± 0.001

* Dry basis amounts expressed in percentage (%).

Experimental design

There was a design of completely randomized experimental classification of fixed effect, balanced with a single Sacha inchi seed, with four levels of treatments (F0, F5, F7.5, and F10). The prototype draft type food was taken as experimental unit; physico-chemical analysis was performed with fatty acid profile that was analyzed statistically by multivariate analysis of variance MANOVA. The results were generated using SAS University Edition (SAS Institute, 2011), with a confidence level of 95%.

RESULTS

Physicochemical analysis

Physicochemical data seed Sacha inchi is shown in Table 2.

Fatty acid profile of sacha inchi seed

Values were found of polyunsaturated fatty acids such as linolenic acid (n-3) of 19.94% and linoleic acid (n-6) with 13.77% in Sacha Inchi; the values were equally highlighted as a percentage of palmitic fatty acids Saturated with 1.85 ± 0.005. The monounsaturated oleic acid percentage of 3.40 ± 0.009 was obtained (Table 3).

Chemical analysis of the prototype food

The analysis of the prototype chemical properties for the different treatments is shown in Table 4, with values of humidity between 10.3% for F0 and 3.7% for F10; fat showed 0.83% in the treatment of F0 and 4.82 in the treatment of F10. The percentage of protein is found between 15.1% for F0 and 15.8% in F10.

Fatty acid profile of the prototype food

A significant statistical difference ($p<0.05$) (Table 5) between treatments for fatty acids (lauric, palmitic, stearic, palmitoleic, oleic, Cis-11-eicosenoic, linoleic, α-linolenic) was found, with the highest content of the n6 linoleic fatty acid in treating F10. The values obtained from the profile for the treatment of F0 (white) were

Table 4. Compositional analysis food type prototype by treating Sacha inchi.

Parameter	F0	F5	F7.5	F10
Fat (%)	0.83	3.15	3.82	4.82
Protein (%)	15.1	15.8	14.9	15.8
Humidity (%)	10.3	6.0	6.6	3.7
Ash (%)	4.80	4.35	5.20	4.50

Table 5. Acid profile of fatty food type prototype by treating Sacha inchi.

Fatty acid profile	Fatty acids	Treatments			
		F0	F5	F7,5	F10
Saturated fat	C14: 0 (lauric acid)	0.0102 ^{c}	0.015^{b}	0.0193^{a}	0.0091^{d}
	C16: 0 (myristic acid)	0.02^{a}	0.0216^{a}	0.0222^{a}	0.0224^{a}
	C17: 0 (palmitic acid)	0.5358^{d}	0.6051^{c}	0.6686^{b}	0.7281^{a}
	C18: 0 (stearic acid)	0.2044^{d}	0.253^{c}	0.3006^{b}	0.3517^{a}
Monounsaturated fat	C16: 1 (palmitoleic acid)	0.0426^{a}	0.0318^{c}	0.0298^{c}	0.0399^{b}
	C18: 1n9c (oleic acid)	0.3961^{d}	0.5472^{c}	0.6929^{b}	0.8102^{a}
	C20: 1n9 (cis-11-eicosenoic acid)	0.0127^{d}	0.0155^{c}	0.0182^{b}	0.0324^{a}
Polyunsaurated fat	C18: 2n6c (linoleic acid)	1.0611^{d}	1.5899^{c}	2.0425^{b}	2.6315^{a}
	C18: 3n3 (a-linolenic acid)	0.0747^{d}	0.9324^{c}	1.6381^{b}	2.4355^{a}

*Amounts expressed in percentage (%) dry basis. Media in the same row with different letters indicate statistically significant difference ($p< 0.05$).

Table 6. Percentage of acceptance of the prototype food.

Parameter	F0	F5	F7.5	F10
Color	100.0^{a}	96.7^{a}	97.0^{a}	100.0^{a}
Odor	100.0^{a}	90.0^{a}	100.0^{a}	100.0^{a}
Flavor	92.9^{a}	83.3^{a}	94.1^{a}	84.4^{a}
Texture	85.7^{a}	90.0^{a}	91.1^{a}	90.6^{a}

Different superscripts indicate significant statistical difference ($p <0.05$).

0.7704 ± 0.0032; 0.4514 ± 0.0010 and 1.1358 ± 0.0002; while for the treatment of 10, values obtained were 1.1113 ± 0.0013; 0.8825 ± 0.0007 and 5.0670 ± 0.0154for total saturated fatty acids, monounsaturated (MUFA) and polyunsaturated PUFA, respectively. Similarly, an increasing trend of saturated fatty acids was found (MUFA and PUFA) in each of the treatments with regard to white (F0).

Sensory analysis

No statistical difference between treatments was detected by applying multivariate technique MANOVA, to jointly evaluate the sensory variables ($p> 0.05$). 100% of the consumers accepted the color and odor for the F0 and F10. It was also observed that the flavor and texture in general presented percentages of acceptance that ranged between 83.3 and 92.9% for the different treatments (Table 6).

DISCUSSION

The moisture content in the seed of Sacha inchi is within the range of 0 to 13% as reported by (James, 1995), who described this value as suitable for the storage and processing without degradation of triaglycerols by

microorganisms. The protein content of the seed of Sacha Inchi analyzed in this study was similar to that reported by (Gutiérrez et al., 2011) with 24.7% and was slightly lower than that found by (Cisneros et al., 2014) with 27% w/w. These percentages can be related to other oil seeds such as sesame (~25%), peanut (23% w/w) and sunflower (24% w/w) (Bodwell and Hopkins, 1985) to help meet the daily protein requirements for adults (0.66 g/kg per day), as suggested by the World Health Organization (Joint FAO, World Health Organization, 2007).

The lipid content of the Sacha inchi are consistent with those reported by other authors (Bondioli et al., 2006) and (Follegatti-Romero et al., 2009) that found the characteristic values of oil seeds to be between 30 and 54% (McKevith, 2005). Notably, the Sacha inchi analyzed in this work has high lipid content as found with regard to chia seeds (26.7 to 35%), safflower (27.5%) and soybeans (16.5%) (Chirinos et al., 2013).The values of Polyunsaturated Fatty acids (PUFA), linolenic (n-3) and linoleic acid (n-6) found in this study are lower than those reported by other authors (Gutiérrez et al., 2011) and (Garmendia et al., 2011). The differences can be attributed to weather conditions and physiological maturity of the fruit (Ruiz et al., 2013). According to Gebauer et al.(2006), in relation to the recommendations of ω-3 and source food with benefits for cardiovascular health, about 2 g/day are suggested; which implies that the seed itself may be a food source of ω-3 cardio-protective benefits. Considering the effect of the addition of Sacha inchi in treatments, these increased to 3 times the total lipid content and about 4 times the content of PUFA in the treatment of F10 with regard to white (F0). Similarly, there was a decrease in the percentage of moisture in the prototype food draft type, which can reduce microbial growth as an indicator of the useful shelf life of the product.

In relation to the data obtained in the fatty acid profile of the prototype, the food draft showed significant differences ($p<0.05$) in the values of ω-3 between treatments F0: 0.07%; F5: 0.9%; F7.5: 1.6% and F10: 2.4%; and for ω-6 and there were significant differences ($p<0.05$) between treatments F0: 1.0%; F5: 1.6%; F7.5: 2% and F10: 2.6%. Baéz Pazmiño et al. (2013 b), developed an energy bar with addition of Sacha inchi seed and other lipid materials reporting values of ω-3 (6.2%) and ω-6 (3.1%) (46), which when compared with the values of ω-3 and ω-6 were lower compared to those found in this study. However, prototype of the drafted food developed from the treatment of F5 can be considered high and a good source of omega 3, according to resolution 333 of 2011 requirements for nutrition labeling of the Ministry of Social Protection in Colombia (Resolución 333 de 2011). Addition of Sacha inchi seed does not significantly change the acceptance of consumers who evaluated the prototype of the drafted food type; even by permitting the addition of this oilseed with high nutritional value without altering the sensory characteristics by up to 10% food. Similarly, Marpalle et al. (2014), developed functional bread with added flaxseed flour, where they found acceptance in the sensory parameters evaluated with 10% added of wheat flour flaxseed.

Conclusion

The Sacha inchi is a food containing polyunsaturated fats and a good source of protein. Incorporating Sacha inchi seeds in a new prototype of food such as a snack could be considered as a novel and nutritious ingredient. Levels from 5% Sacha inchi seed are allowed for declaring the foodstuff as a high and good source of ω-3. The sensory evaluation revealed an acceptance of the prototype food developed, which added up to 10% of Sacha inchi seeds, which can be a potential health benefit due to the content of ω-3, to which they have been described a protective effect against cardiovascular diseases.

Conflict of Interests

The authors have not declared any conflict of interests.

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