Nutritional and Chemical Characteristics of Zambo Seed (Cucúrbita Ficifolia) for Use in Obtaining Vegetable Oil. A Review

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Abstract: The present work corresponds to a bibliographic research regarding the nutritional and chemical characteristics of the sambo seed (Cucúrbita Ficifolia), where it is assumed as a problem the lack of knowledge by the general population regarding the benefits that this product presents in food and medicine. The nutritional value presented by the sambo seed, usually oval, is through carbohydrates, healthy fats, proteins and fiber where the seeds are the most important product for its high oil content of 39% and 44% in protein; the benefits of consuming these seeds are health care, helps treat anti-inflammatory and antioxidant diseases, diabetes, obesity, hypertension. Zambo seeds have chemical and nutritional properties which are intended to be used responsibly in the manufacture of vegetable oil, contributing to health care with this product. These physicochemical properties are omega 3 and 6, potassium, phosphorus, vitamin A and E, B complex, magnesium, calcium, iron. Vegetable oil is obtained through 2 methods, the first one is the mechanical extraction that consists of breaking the cell walls of the seed and the second one is the chemical extraction where ethanol, ethyl ether, hexane and isopropanol are used directly from the oleaginous seed where its main component is the triglyceride; it is very important the treatment that the seed receives from the harvesting of the fruit to the industrial process to have a quality product.

Keywords: Seed, Zambo, Vegetable Oil, Fatty Acids, Pumpkin, Cucurbita

1. INTRODUCTION

The zambo is one of the vegetables that have been cultivated for thousands of years, mainly for its fruit (rich in carbohydrates and vitamins), but also for its seeds, rich in oil and proteins. Pumpkin species are very diverse, mainly due to the shape, size and color of their fruits (Pérez, 2017). Therefore, it seeks to define the nutritional and chemical characteristics of the zambo seed (*Cucúrbita Ficifolia*) for its use in obtaining vegetable oil.

The pumpkin (*Cucúrbita Ficifolia*), with favorable properties and its constant consumption offers important benefits, due to its magnesium content that favors the production of blood tissue (Pérez, 2017). Currently Sambo seeds (*Cucúrbita Ficifolia*) are constantly discarded because society lacks the knowledge about the benefits and productive that these can become. It should be noted that today the consumption, production of zambo (Artiega, Baqueriso, Rosales, & Rodríguez, 2016)*(Cucurbita Ficifolia)* And its use in the Ecuadorian food industry is quite scarce, because its cultivation is done in an artisanal way. (Artiega, Baqueriso, Rosales, & Rodríguez, 2016)

In addition, the seeds have important nutrients suitable for consumption such as unsaturated fatty acids, minerals, proteins and given their protein value highlights their content in essential amino acids (the human body is not able to create them so it is vital to include it in food) such as cystine, alanine, tryptophan and glycine that are also

present in these seeds, They are useful for tissue repair and serotonin activation. Since, its seeds are used for the production of vegetable oil, becoming an alternative consumption compared to what exists in the market. (Moncayo, 2017)

Good nutrition is a human right, so the nutritional and chemical properties of zambo seeds *(Cucurbita Ficifolia)* must be used to create a product that contributes to human well-being. Therefore, an analysis of the same is carried out, due to the properties of the seeds, which have been unnoticed for their high nutritional value.

2. ZAMBO (*CUCURBITA FICIFOLIA*) ORIGIN

Its scientific name comes from the Latin ficifolia, "fig leaves". As for the origin of the genus *Cucúrbita* It is native to the American continent, commonly known as pumpkins. In particular, the region comprising Mesoamerica and North America are the center of origin and diversification of the five domesticated species of the family. *Cucurbitácea* Where the Zambo is located *cucúrbita ficifolia* (Barrera, 2020). According to Mexico, it is considered the most important center of origin and domestication of the genus. (Garza, 2021)*Cucúrbita* as it is the country where four of the five domesticated species are cultivated.

Constituent	Tender	Ripe
Humidity %	94,5	91,4
Protein %	0,3	0,2
Fat %	0,1	0,5
Total Carbohydrate %	4,4	6,9
Crude Fiber %	0,5	0,6
Ashes %	0,2	0,4

Varieties	
Common name	**Scientific name**
Pumpkin	*Cucurbita Ficifolia Bauche*
Loche	*Cucúrbita mostacha Dushenes*
Pumpkin	*Cucúrbita maxima Dushenes*

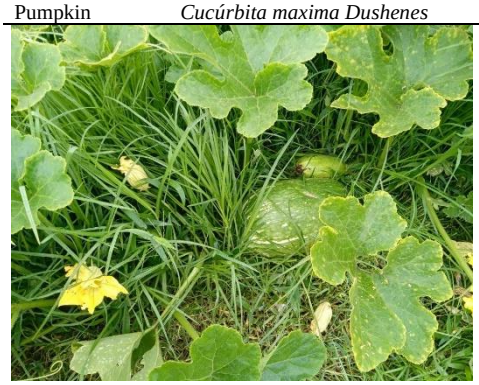

Figure 1. *Partner*

Source: Adapted from (Authors)

2.1. Varieties

From the family of the *Cucurbits* three varieties are known as indicated in the following Table 1 (Houses, 2020). Both the *cucúrbita ficifolia* and the *Cucurbita maxima Dushenes*, both species are cultivated for food, taking advantage of their tender and ripe fruit. (Marín, 2019)

Board 1. Varieties

Source: Adapted from Casas (2020), Martin (2019)

2.2. Nutritional value of sambo

The proximal chemical composition of zambo is shown in Table 2. It varies within a range that depends not only on the variety, but also on growing conditions, climate, fertilization and harvest time. (Moncayo, 2017) (Moncayo, 2017)

Board 2. Proximal chemical composition of sambo

Source: Adapted from Moncayo (2017)

2.2.1. Nutritional value of sambo seed

The nutritional value of zambo seeds is due to the presence of nutrients with their availability indicated in the following Table 3 (Quispe, 2021).

Board 3. Nutritional value of the seed

Nutritional value of sambo seed	
Nutrients	**Availability**
Carbohydrates	10%
Healthy fats	50%
Proteins	30%
Fibre	7%

Source: Adapted from Quispe (2021)

3. Characteristics of seeds

The seeds are oval in shape, weighing approximately between 50 and 250 mg (Marin, 2019). As they mention that through an analysis of variance the length, thickness and width of the seed, has the following averages of length 20.61 mm, width 8.59 mm, thickness 2.51 mm. The absolute variance is 3.18 mm for length, 0.50 mm for width and 0.14 mm for thickness with a standard deviation ± of 1.78 mm length, 0.71 width, mm and 0.37 mm thickness.(Ortiz, Amante, Durán, & López, 2018)

The seeds of the *Cucúrbita ficifolia* They are appreciated for being oilseeds with food, medicinal and industrial properties. Seeds are the most important product because of their high oil content of 39% and protein content of 44%.(Rodríguez, 2018)(Valdés R, 2019)

3.1. Uses of the seed

Zambo seeds (*cucúrbita ficifolia*), since ancient times, are credited as natural ingredients with healing properties. These seeds can be used for human food due to their high lipid and protein content, and also has pharmacological properties to treat anti-inflammatory and antioxidant diseases.(Artica & Baquerizo, 2018) (Hernandez, Martinez, & Gordillo, 2019)

These seeds can be used to make snacks and pasta that is used in restaurants, . Also, to obtain essential oils for consumption, due to its high fat content.(Ruiz, 2018) (Zambrano, 2018)

3.2. Proceeds

The seeds are beneficial to human health, they can be considered as a natural functional food like phenols. According to him, he mentions that the consumption of zambo seeds helps reduce diseases such as diabetes, obesity and hypertension. In addition to being a very nutritious and delicious food, zambo seeds also have extraordinary properties to treat certain diseases such as rheumatic, diarrhea and strengthens the brain. (Lemus, 2019).(Marín, 2019)(Velandia L. J., 2020)

4. NUTRITIONAL AND CHEMICAL PROPERTIES OF ZAMBO SEED

4.1. Fatty Acid Composition

Fatty acids are the main source of lipids that are of great importance for the diet. (Baquerizo, 2017 & Hernández, 2018).

Fatty Acids	
Components	**Availability**
Unsaturated fatty acids	78% a 80 %
Linoleic	38,40%
Oleic	34,60%
Palmitic	17,80%
Stearic	9,36%

Board 4. Fatty Acids

Source: Adapted from Baquerizo (2017)

4.2. Chemical properties

They are very rich in omega 3, omega 6 fatty acids, and have many vitamins and minerals such as potassium, phosphorus, vitamins A and E. They have a fat content of 32.6% and are a good source of vitamin A, and B complex (B1, B5, B6, B12), also has 31.3 mg of calcium, iron in 6.8 mg, as well as potassium has fiber and water (Ruiz, 2018)(Marin, 2019).

5. PROCESSES FOR OBTAINING VEGETABLE OILS FROM SEED SPECIES

5.1. Vegetable oils

Vegetable oils are organic compounds obtained from oilseeds, whose main components are fatty acid triesters, glycerol which is called triglycerides, these oils can be formed by a single type of triglyceride or by a mixture of these. All vegetable oils provide and participate as transporters of fat-soluble vitamins, such as A, D, E, and K.. They are not only used for food purposes, but also for industrial purposes. Depending on the type of seeds, different methods

of extraction and processing are used, this is because it is necessary to separate the liquid part (oil) from the solid part.(Sánchez & Zavaleta, 2018) (Espinosa, 2019) (Durán, Torres, & Sanhueza, 2018)(Gadón, Torres, & Garcia, 2017)

5.2. Types of vegetable oils

Most of the time, oils are obtained from the seeds, so sunflower, rapeseed or corn oil reaches our table by subtraction (mechanical or chemical) of the seeds of these plants. (Baquerizo, 2017). However, as mentioned above, there are also fruit oils such as avocado, olive, or palm oil as indicated in Table 5 below, .(Hernández, 2018)

Board 5. Types

Main uses	Specific Uses	Sources
Alimentary	Cooking oil (Domestic)	Corn, Sunflower, Canola, Avocado
	Cooking oil (Industrial)	Palm and Coconut
	Dressing	Olive and Avocado
	Additive (Hydrogenated)	Palm and coconut
	Flavorings	Cinnamon, Citrus, Mint
Industrial	Biodiesel	Maize, Rapeseed and Jatropha
Cosmetics	Humectants and emulsifiers	Olive, Avocado, Almond, Grape
Medicinal	Essential oils with an often triglyceride content are especially handled.	Lavender, Rosemary, Sandalwood

Source: Adapted from Baquerizo (2017) & Hernández (2018)

6. *Oil extraction methods*

According to , there are two more systems used for the extraction of vegetable oil.(Sánchez & Zavaleta, 2018)

- Mechanical extraction
- Solid liquid extraction with solvent (Chemistry)

6.1. Chemical Extraction

Solvents such as ethanol, ethyl ether, hexane and isopropanol are used, as they are capable of removing a higher percentage of oil. The fat content of the seeds or fruits is separated and in this way a mixture of the solvent and the oil is received, it is distilled to eliminate any possible residue of the solvent used this process on several occasions managing to recover 98% of the oil.(Narváez, 2021) (Velandia L. , 2020)

6.2. Mechanical extraction

Mechanical extraction (by pressure), recommended for seed with fat content greater than 20%, . To do this, it must be crushed to break the cell walls of the seed by making them flakes, passing them through rollers or subjecting them to great pressure.(Narvaez, 2021) (Rodriguez & Artea, 2017).

The great advantage of this method is that it is an exclusively mechanical process, without the addition of chemical additives which guarantees a healthier oil that maintains its organoleptic properties (flavor, color, texture). (Céspedes, 2021)

7. *Oil Harvesting*

According to (Rodríguez & Artea, 2017), it mentions that the extraction of oil by the mechanical method or extraction by pressing obtained 32.48% of yield, the solvent method using ethanol as a solvent presented higher performance being 34.69% respectively and the method of lower performance was that of cold pressing that has 32.48%.

7.1. Determination of oil quality

The physical characteristics of an oil and fat are dependent on factors such as the seed or plant of provenance. So the degree of unsaturation, size of carbon chains, isometric forms of fatty acids, molecular structure of triglycerides. Thus we move on to antioxidant activity, oxidation stability (peroxide formation), refractive index as an indicator of purity and saponification capacity as an indicator of increase and efficacy of fatty acids. According to the standard ((Vera, 2019)(Cruz, Chavez, & Fernández, 2021) (Montalva, 2016)INEN 34, 2012), establishes that the mixture of edible vegetable oils being a compound oil, obtained by mixing vegetable oils subjected or not to modification processes such as winterization and fractionation. Any mixture of edible vegetable oils must be refined, have a clear appearance at 25°C, and have a pleasant smell and taste; it must not contain foreign matter, substances that modify its aroma or color, or residues of the substances used for its refining, they must comply with the specifications established in Table 5.

Board 6. Specifications of edible vegetable oils

Requirements	Unit	Minimal	Maximum	Test method
Free acids (such as oleic acid)	%	−	0,2	NTE DESCENDING 38

Heat loss	%	–	0,05	NTE DESCENDING 39
Refractive index at 25 °C	–	1,454	1,476	NTE DESCENDING 42
Peroxide content	meqO_2 /kg	–	10	NTE DESCENDING 277

Source: Adapted from Ecuadorian Institute for Standardization (INEN 34)

8. *Treatment of sambo seed to obtain oil*

This process is carried out from collection, transport and rigorous cleaning to remove metals, dirt, stones and foreign seeds. To later move on to the process of drying the seeds, and continues to the state of husking, in the last stage this must be ground creating a paste which will allow us to obtain the oil. (Callata, 2018) (Sánchez & Zavaleta, 2018)

8.1. Extraction methods

The most commonly used methods for these types of vegetable oil are two. (Cordova & Mendoza, 2021)

- Mechanical method (pressure)
- Solid liquid method with (solvents)

8.1.1. Mechanical pressure extraction

For the extraction of oil from oilseeds, pressure subtraction is used when the oil content is greater than 20%. This method consists of breaking the walls of the cells that contain it, this can be achieved by passing them through rollers or subjecting them to great pressure. (García, 2022)(Kipping, 2018)

Oils obtained without heating, that is, in a cold state, contain a lower proportion of impurities and their quality is buna that they are usually edible without further purification or processing. Pressing the copra cake while it is heating extracts more oil, in addition, it presents a large proportion of impurities of non-glyceric nature (phospholipids, pigments, unsaponifiables).(Villarde, 2018) (Laurel, 2019)

8.1.2.Liquid solid extraction (solvents)

Vegetable oil is solid-liquid subtraction or leaching with organic solvents. The seed oil is diffused and extracted with the help of the solvent, so that the protein remains in the surplus with fiber and carbohydrates. In addition, the cakes received after pressing, which usually contain between 3 and 15% residual oil. (Santana, 2019) (Contreras, Sánchez, Dueñas, & Dueñas, 2022)

8.2. Fatty acid profile analysis of the oil

The seed oil of *Cucúrbita ficifolia* It has a high content of linoleic acid with values of 58.99%, 68.39% and 65.22% respectively. This may be due to factors such as climate and place of origin of the seed.(Chaves, 2020)(Cabrera, 2020)

8.3. Analysis of the chemical properties of Cucurbita ficifolia seed oil

Table 6 reports the results referring to the chemical characteristics of the oil obtained from *Cucúrbita ficifolia* determined according to the recommended methodology Association of Analytical Communities International (AOAC). (Artiega, Baqueriso, Rosales, & Rodríguez, 2016)

Board 7. Chemical properties of seed oil *Cucúrbita ficifolia*

	Pressing (Mechanical)	**Solvent**
Acid number (mg oleic acid)	2,30±0,27	2,70±0,14
Saponification index (mg KOH/g)	191,77±2,73	193,53±0,71
Peroxide content (meq O2/ 1000g)	1,30±0,039	2,02±0,061
Iodine Index(g/100g)	113,17±7,09	103,06±0,59
Refractive index (40)	1,47±0,001	1,47±0,004
Density (g/cm3) at 20ºC	0,91±0,002	0,92±0,003

Source: Adapted from Arteaga, Baquerizo Rosales & Rodríguez (2016)

In this Table 8, where the chemical parameters that were taken into account for the determination of quality are exposed, these based on the INEN 26: 2012 Standard for seed oil.

Table 8. Chemical analysis of pumpkin seed oil

Parameter	Method
PH	INEN ISO 4316/pH-metro digital/
Acidity	INEN ISO 660/ acidity method
Iodine index	INEN ISO 3961 / Iodine Index
Heat loss	INEN ISO 662/heating loss method
Refractive index	- INEN ISO 166 / refractive index
Peroxide content	- INEN ISO 3960/ peroxide index
Relative density (25 ℃)	INEN ISO 35/picnometer method

(Cucurbita ficifolia)

Source: *(NTE INEN 2012)*

8.4. Uses of oil extracted from sambo seed

Vegetable oil extracted from seeds has multiple applications, such as food, cosmetics, and biofuels. (Juárez, 2018)

9. DISCUSSION OF RESULTS

Pumpkin seeds are a good source of healthy fatty acids, especially oleic and linoleic acid. The effect of the factors: time, temperature, particle size and solvent volume on the extraction performance. To know the effect of time, oil was extracted at 60 ° C, with particle diameter of 1.65 to 2.23 mm for 1, 2, 10, 20, 30 and 60 min. At the temperature of 30, 40, 50 and 60 °C, for 60 min, with diameter of 0.85-1.65 mm. For the effect of particle size, 3 diameter ranges were used: less than 0.85 mm, 0.85-1.65 mm and 1.65-2.23 mm, extracting at 60 °C for 60 min. For the effect of the volume of the solvent was used: 15, 20, 25, 30 and 35 mL of hexane at 60 ° C for 60 min. By increasing the temperature, time and volume of solvent, the yield was increased.

Seed oil yield.

Duplicates were made for the extraction of pumpkin seed oil, using the traditional method and with ultrasound at different times (5-30 min) and amplitudes (25-100%). The amount of oil extracted was 8,685 g on average which corresponds to 43.69% of the oil contained in the pumpkin seed, based on 20 g of seed.

Fat profile analysis

The seed oil of *Cucúrbita Ficifolia* obtained by 3 subtraction processes has a high content of linoleic acid (C18:2, ω-6), values of 58.99%, 68.39% and 65.22% respectively.(Cárdenas, 2022)

The content of linoleic acid shows a statistical change of 0.01 and 0.05.of the three treatments, the highest average value extracted under pressure with solvent ethanol, hexane and oleic acid shows statistical variation, with the highest average value. (Cárdenas, 2022)

According to the data, the oil extracted by the traditional method is rich in stearic, palmitic and oleic acids, so its incorporation into the diet favors the diffusion of cholesterol, since oleic acid allows to decrease the density of the lipid bilayer and palmitic acid contains antioxidant capacity.

Free fatty acids (FFA)

For free fatty acids, a higher value than expected was obtained, since the Mexican standard states that for edible vegetable oils the maximum acidity value must be 0.05% (NMX F223-1985). This high degree of acidity could have been caused by two factors: the first is that no care or heat treatment has been given to the flours of the seeds prior to the extraction of the oil, so there was no inactivation of the lipase enzymes responsible for the degradation of triacylglycerides releasing free fatty acids, The other factor of influence is the moisture content of the seed, at first the oil was extracted without drying the flour, so the high percentage of moisture favors the hydrolysis of triacylglycerides.

10. CONCLUSIONS

The seeds of the zambo have nutritional and chemical properties, which are sought to take advantage of responsibly in the manufacture of vegetable oil, which contributes to the well-being of the human being, since they have a high content of fatty acids such as omega 3 and 6, also has vitamins and minerals, its fat content is 32.6%. These seeds can be used in human food, due to their high content of lipids and proteins, also has pharmacological properties that are of great benefit to society, as well as its extraction of vegetable oil from the seeds.

The obtaining of vegetable oil is obtained through 2 methods, mechanical extraction that consists of breaking the cell walls of the seed, so it is a mechanical process, without the addition of

chemical additives which guarantees a healthy oil maintaining its organoleptic properties, therefore, a 32.48% yield was obtained and the other method used is chemical extraction where ethanol is used, ethyl ether, hexane and isopropanol directly in the oilseed where its main component is triglyceride and this presented a higher yield being 34.69%.

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