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# *Lecythis pisonis* Camb. nuts: oil characterization, fatty acids and minerals

M.I. Vallilo [a,*], M. Tavares [b], S. Aued-Pimentel [b], N.C. Campos [b], J.M. Moita Neto [c]

[a] *Woods and Forest Products Section, Dasonomy Division, Forest Institute, PO Box 1322, 01059-970 São Paulo, SP, Brazil*
[b] *Oils, Fats and Spices Section, Bromatology and Chemistry Division, Adolfo Lutz Institute, PO Box 1783, 01059-970 São Paulo, SP, Brazil*
[c] *Department of Chemistry, Federal University of Piauí, PO Box 64, 049-550 Teresina, PI, Brazil*

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**Abstract**

The lipid content, the acid value, refractive and iodine indexes, the oil fatty acids profile as well as the concentration of inorganic elements contained in the *Lecythis pisonis* Camb. (Lecythidaceae) nuts were determined. The samples came from four different regions in São Paulo State, Brazil. The samples showed a high lipid content (34.2 to 61.3%) that presented a fatty acid profile, an iodine value and an index of refraction equivalent to the corn oils. Among the macronutrients, high levels of P (5.2 to 6.2 mg $g^{-1}$) and Sn (69.1 to 77.0 μg $g^{-1}$) were observed in all the nuts. High levels of Pb (3.3 to 3.8 μg $g^{-1}$), Cu (2.9 to 3.3 μg $g^{-1}$), Zn (2.6 to 3.8 μg $g^{-1}$) and Mn (4.0 to 11.6 μg $g^{-1}$) were found. It is evidence of a possible toxicity and it could compromise the use of the *L. pisonis* nuts for human consumption. 

*Keywords:* *Lecythis pisonis* Camb.; Sapucaia; Lipids; Fatty acids; Inorganic elements

## 1. Introduction

Fruits and seeds of some species found in the Brazilian forests have shown to be good sources of nutrients. Brazil nuts (*Bertholletia excelsia* Humb. and Bonpl.) native of the Amazon region (Cavalcante, 1996) and the pequi (*Caryocar brasilienses* Camb.), collected in the region of Campo Grande, capital of the State of Mato Grosso do Sul (Hiane, Ramos, Ramos Filho, & Pereira, 1992) are examples of calories and fatty acids sources. However, many other types of fruits from the vast Brazilian territory should be analyzed as regards its chemical composition, so that the data obtained can contribute to the creation of food composition tables as well as to the establishment of procedures for stock or storage, in order to preserve their viability or germinate power.

As can be found in specific literature, seeds with high lipid content lose their viability throughout time. Kaloyeras (1958), using *Pinus* seeds, showed the relationship between the fixed oil rancidity development and the loss of the germinate power.

Nowadays research as well as the production of oleaginous seeds and fruits have been growing considerably as a source of raw material for the oleochemical industry, representing 70% of all the oils obtained from natural sources that are mostly used by the food industry (Freire, dos Santos, & Beltrão, 1996).

*L. pisonis* Camb. (sapucaia) nuts, is commonly used as an edible part of the fruit in the interior of Brazil, especially in the region that comprises the states of Pernambuco through São Paulo and in the Amazon region (Mori & Prance, 1990). Nevertheless, there is little knowledge of its chemical composition and nutritional value.

The goal of this work was to characterize the oil of *L. pisonis* nuts and determinate the fatty acids and some minerals in these nuts from different locations in São Paulo State. The results will help to evaluate:

- the potential use of the seeds as an alternative source for the food or oleochemical industries, and
- the storage procedure in order to fulfill the requirements of planting and reforestation programs.

## 2. Materials and methods

The *L. pisonis* fruits were collected in the four different localities (Tupi, Santa Rita do Passa Quatro, Piracicaba and Nova Europa) located in São Paulo State,

* Corresponding author.

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Brazil. The fruits were collected from about five trees that occur spontaneously in each region. The nuts were taken off from the fruits. The nuts from each locality were ground and homogenized using a food processor in the laboratories of Forest and Adolfo Lutz Institutes, São Paulo.

The lipids were hot extracted from the nuts by the Soxhlet method, as described in *Normas Analíticas do Instituto Adolfo Lutz* (Instituto Adolfo Lutz, 1985), except for the sample that came from Tupi, where cold extraction was applied using the Stansby method (Stansby & Lemon, 1937).

The fatty acids composition was determined by gas chromatography. Fatty acids methyl esters were prepared in accordance with the *Normas Analíticas do Instituto Adolfo Lutz* (Instituto Adolfo Lutz, 1985).

The fatty acids methyl esters analyses were carried out with a gas chromatograph equipped with flame ionization detector coupled to an integrator. The components were separated into a 30 m Supelcowax 10 fused silica capillary column with a film thickness of 0.25 μm (micro) and an internal diameter of 0.25 mm. The following operating conditions were observed: column temperature programmed from 100 to 230°C (10°C/min); injector temperature, 240°C; detector temperature, 240°C; hydrogen carrier gas (gas flow rate of 0.8 ml/min); sample split ratio, 1:100. Fatty acids methyl esters were identified with individual standards. The quantification was made by area normalization.

The acid value and the refractive index (40°C) were determined by the methodology described in *Normas Analíticas do Instituto Adolfo Lutz* (Instituto Adolfo Lutz, 1985). The iodine value was calculated by the AOCS Cd 1c-85 method (American Oil Chemists' Society, 1990), based on the unsaturated fatty acid composition.

In order to determine the macro and micronutrients, wet analysis was applied to the samples, at the laboratory of Atomic Emission Spectrometry of the Chemistry Institute of the University of São Paulo (USP), using microwave radiation in a rapid digestion system, according to the method specified in the equipment manual (Rapid Digestion System MX-350 SPEX Manual, 1991) under the following operating conditions:

- **1st STAGE**: 10.0 ml of $H_2SO_4$ conc. and 5.0 ml of $H_2O_2$ at 30% (v/v) were added to the sample (0.5 g); power of 60 W was applied for 5 min;
- **2nd STAGE**: 5.0 ml of $H_2O_2$ at 30% (v/v) was added to the above obtained mixture; and again heating for 5 min at an applied power of 90 W;
- **3rd STAGE**: To the mixture obtained in the 2nd stage another 2.0 ml of $H_2O_2$ at 30% (v/v) was added and a heating power of 90 W applied for 5 min.

The solubilized sample was then filtered using a quantitative filter paper and the filtrate was placed in a 50 ml volumetric flask. It was made up to volume with deionized water. A limpid pale yellow solution (50.0 ml) resulted by means of which the inorganic elements were quantified.

An ICP–AES sequential spectroflame (Spectro) was used for wavelength determinations and instrumental conditions are presented in Table 1.

Stock solution (1000 μg liter$^{-1}$) of the Mg (II), P (VI), Ca (II), Mn (II), Sn (IV), Cu (II), Zn (II), As (III), Cd (II) and Pb (II) were prepared from appropriate amounts of salts in solution of $HNO_3$ conc. at 10% (v/v) and water distilled and deionised (Permution Deionizador).

Table 2 shows the wavelengths and the detection limits for the elements studied. The detection limit was defined as that concentration of analyte which gives a response equal to 3 times the standard deviation of the blank.

Acids and other reagents used in the work were analytical grade (Merck, Johson Matthey).

All determinations were done in triplicate with the exception of inorganic nutrients with five repetitions.

## 3. Results and discussion

On average the samples from four different regions of the State of São Paulo, showed a high lipid content as presented in Table 3. Samples from Nova Europa showed lipid contents closed to the values referred in the literature, i.e., 62.60% (Franco, 1992). However, these samples presented the lowest level of linoleic acid

Table 1
Instrumental conditions of the ICP–AES

| | |
|---|---|
| Rf forward power | 1.2 kW |
| Plasma gas flow | 12.0 liter min$^{-1}$ |
| Auxiliary gas flow | 1.2 liter min$^{-1}$ |
| Carrier gas flow | 1.0 liter min$^{-1}$ |
| Observation height | 12 mm[a] |
| Sample flow | 1.5 ml min$^{-1}$ |

[a] Observation height above the copper coil of ICP–AES.

Table 2
Wavelengths and detection limits for the elements

| Elements | λ (nm) | L.D (μg ml$^{-1}$) |
|---|---|---|
| Mg | 285.210 | 0.0810 |
| P | 214.902 | 0.0869 |
| Ca | 317.940 | 0.0137 |
| Mn | 257.615 | 0.0037 |
| Sn | 189.926 | 0.0040 |
| Cu | 324.503 | 0.0040 |
| Zn | 344.503 | 0.0077 |
| As | 188.979 | 0.0080 |
| Cd | 226.502 | 0.0010 |
| Pb | 283.307 | 0.0057 |

Table 3
Lipid contents and main fatty acid composition of *L. pisonis* nuts from various regions of São Paulo State expressed in p/p (%) in methyl esters[a]

| Samples | Lipids (%) | C 16:0 Palmitic acid | C 18:0 Stearic acid | C 18:1 Oleic acid | C 18:2 Linoleic acid | Total SFA[b] | Total UFA[b] | Calculated iodine value | Refractive index (at 40°C) | Acid value (mg KOH/g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Tupi | | | | | | | | | | |
| Mean ± σ | 34.2 ± 1.3 | 10.9 ± 0.1 | 7.7 ± 0.8 | 27.0 ± 0.5 | 54.2 ± 1.4 | 18.6 | 81.2 | 117 | 1.465 | 1.80 |
| Sta Rita do Passa Quatro | | | | | | | | | | |
| Mean ± σ | 39.7 ± 1.1 | 12.8 ± 0.9 | 3.7 ± 1.1 | 27.3 ± 1.8 | 56.3 ± 3.2 | 16.5 | 83.6 | 121 | 1.464 | 0.52 |
| Piracicaba | | | | | | | | | | |
| Mean ± σ | 51.9 ± 0.7 | 8.6 ± 1.3 | 3.5 ± 0.8 | 39.9 ± 0.9 | 48.0 ± 2.4 | 12.1 | 87.9 | 117 | 1.461 | 0.53 |
| Nova Europa | | | | | | | | | | |
| Mean ± σ | 61.3 ± 0.5 | 10.4 ± 0.8 | 7.6 ± 0.9 | 43.0 ± 0.8 | 38.9 ± 1.1 | 18.0 | 81.9 | 104 | 1.465 | 1.30 |

[a] Mean obtained from three determinations and respective standard deviations.
[b] SFA, saturated fatty acids; UFA, unsaturated fatty acids.

(38.90%) among all the analyzed samples and consequently, the lowest iodine value (104). In the other samples, the linoleic acid was predominant. This acid is an essential fatty acid and plays an important role in the germination process of the seeds, showing higher values for the iodine value as can be observed in the samples that came from Santa Rita do Passa Quatro.

Comparing the data obtained in this study to the data from a preview paper with *L. pisonis* seeds collected in Santa Rita do Passa Quatro (Vallilo, Tavares, Aued-Pimentel, Badolato, & Inomata, 1998) a significant decrease in the lipid content was observed, respectively, from 63.03 to 39.72%. However, a significant increase in the linoleic acid content, from 48.60 to 56.30%, was verified.

The oily fraction of all samples showed highly unsaturated mainly the ones from Piracicaba whose total of unsaturated fatty acids was approximately 88%. This characteristic associated to a high lipid content makes it possible to use the sapucaia oilseed for human consumption. However in-depth studies should be done regarding the oxidative stability aiming at its industrial application.

The samples from the four analyzed regions showed a fatty acid profile and a calculated iodine value average equivalent to the standards applied by *Codex Alimentarius* (Codex Alimentarius Commission, 1993) for edible corn oil, except for the stearic acid (C18:0) of the samples from Tupi and Nova Europa. The refractive indexes obtained for these two samples were within the expected range for the above mentioned oil, while the other two samples varied slightly from the lowest minimum limit referred to in the literature (1.465).

Concerning the quality of the extracted oils, the acid values found for all the samples were within the international standards for the processing of crude vegetable oils for human consumption (Pritchard, 1983).

Samples collected in Santa Rita do Passa Quatro and Piracicaba, showed acid value below the maximum limit established for refined corn oils, i.e., 0.6 mg of KOH $g^{-1}$ of oil (Codex Alimentarius Commission, 1993).

The mineral composition obtained for the nuts samples are presented in Table 4. High levels of P and Sn were found in all the samples, mainly the ones collected in Nova Europa whose levels are equal to 6.23 mg $g^{-1}$ and 77.00 μg $g^{-1}$, respectively.

Samples from Tupi show high levels of Pb and Cu and significant quantities of Zn and Mn. The levels of Pb are 6 to 7 times greater than the maximum limits allowed by the Brazilian legislation (Brasil, 1990). In these samples, it was not possible to hot extract the fats by the Soxhlet method to determine the fatty acids, which shows significant variations in the unsaturated acid content in each of the triplicated samples.

The average value obtained for the acidity for the samples from Tupi was the highest one of all. This high acidity combined with significant levels of Zn and Mn in the same sample might have been the cause for the catalysis of oxidative reactions in its oily fraction, mainly in the unsaturated fatty acids when hot extraction was

Table 4
Macro and micronutrient contents of the *L. pisonis* nuts from four sampled regions in São Paulo State[a]

| Elements | Nova Europa | Piracicaba | Tupi | Santa Rita do Passa Quatro |
|---|---|---|---|---|
| | | mg $g^{-1}$ | | |
| Mg | 1.52 ± 1.52 | 1.68 ± 0.07 | 1.42 ± 0.10 | 1.24 ± 0.10 |
| P | 6.23 ± 0.53 | 5.98 ± 0.22 | 5.56 ± 0.18 | 5.25 ± 0.28 |
| Ca | 0.90 ± 0.08 | 0.84 ± 0.08 | 0.81 ± 0.05 | 0.97 ± 0.16 |
| | | μg $g^{-1}$ | | |
| Mn | 4.05 ± 4.23 | 7.06 ± 3.68 | 11.57 ± 2.56 | 4.08 ± 4.36 |
| Sn | 77.00 ± 8.95 | 73.46 ± 3.76 | 70.36 ± 2.53 | 69.10 ± 9.70 |
| Cu | 3.35 ± 0.23 | 3.17 ± 0.18 | 3.21 ± 0.36 | 2.91 ± 0.13 |
| Zn | 3.57 ± 0.25 | 2.61 ± 0.72 | 13.74 ± 1.03 | 2.92 ± 0.58 |
| As | 1.14 ± 0.08 | 1.18 ± 0.06 | 1.08 ± 0.06 | 1.15 ± 0.09 |
| Cd | 0.26 ± 0.01 | 0.27 ± 0.01 | 0.26 ± 0.01 | 0.27 ± 0.01 |
| Pb | 3.55 ± 0.19 | 3.56 ± 0.27 | 3.29 ± 0.35 | 3.81 ± 0.27 |

[a] Average values of five repetitions with the respective standard deviations.

used. Due to these observations, fat was cold extracted by the Stansby and Lemon (1937) method to determine the fatty acids content in the samples from Tupi.

Samples from Nova Europa, besides a high lipid content also presented high levels of P, which is a nutrient recommended in nutritional diets by the National Academy of Sciences, in the USA (Franco, 1992).

The presence of heavy metals in considerable levels in all the samples, especially Pb, can indicate an anthropic contamination of the four sampled locations in the State of São Paulo.

## 4. Conclusions

The samples showed high lipid contents, mainly the ones from the municipality of Nova Europa. They can be a good source of calories in a nutritional diet.

The fatty acid profile of the analyzed oils indicates a predominance of the linoleic acid, which is an essential fatty acid. This observation can be especially noted in the samples that came from Santa Rita do Passa Quatro.

The high lipid content and the high level of unsaturation of the oils indicate the possible use for human consumption although studies concerning their oxidative stability should be done. The oxidative stability can also determine the viability of the seeds.

The high levels of P in all samples, mainly the ones that came from Nova Europa, reinforce the nutritional importance of the *Lecythis pisonis* Camb. nuts,

The large concentrations of Pb are evidence of a possible toxicity of the analyzed samples and of a probable anthropic contamination of the sampled locations, which compromises the use of the *L. pisonis* nuts for human consumption.

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