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Physico-Chemical and Thermal Analysis of the Favelone and By-Products (*Cnidoscolus phyllacanthus*)

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Abstract: A physico-chemical and thermal analysis has been applied to characterization of foods. Taking into account the problems of desertification and agricultural practices able to provide income to the population at the semi-arid region of Northeastern Brazil, this work presents the results of the physico-chemical and thermal characterization of the favelone seed and by-products (*cnidoscolus phyllacanthus*).

Key words: Favelone, cnidoscolus phyllacanthus, thermal analysis, semi-arid

INTRODUCTION

The *cnidoscolus phyllacanthus* sp. locally known as favelone, deserves its prominence, among of the other plants of this region, due to its resistance to the dry environment and its scattering over a remarkable area of the semi-arid region of Northeastern Brazilian. Consequently, there is the potential of huge amounts of raw material, for the extraction process of the oil and flour by industries. Other factor of great importance is the local of occurrence of the favelone: in semi-arid lands of low fertility, which present small interest for an economical exploitation of the existing cultures (Bezerra, 1992).

Previous studies indicate a good perspective for the utilization of these materials as human and animal food and thus, the possibility of their industrialization (Bzezrra, 1972; Lima, 1986; Duque, 1980). Therefore, this research aims at characterizing the favelone seed and by-products, in terms of their thermal properties (TG/DSC), with the purpose of the application of these materials as an alternative for human and animal food.

MATERIALS AND METHODS

Samples: The seeds of faveleira were collected in experimental unities of EMBRAPA (Brazilian governmental organization for agriculture research) of various regions of the Paraíba state, Brazil. The samples of flour, peel and almond were obtained at different particle sizes, denominated as A and B, whose mean particle sizes are respectively 1.19 cm and 1.64 cm. The faveleira seed oil was extracted according to the procedure used by Ahmad (1988) and its analysis regarding the fatty acid composition was carried out according to the methodology of AOCS, American Oil Chemists Society (1994).

Chemical characterization: The fatty acid compositions were determined using a gas chromatograph equipped with flame ionization detector. The following conditions were used: Carrier gas: Helium (1 mL min^{-1}); Atmosphere: Synthetic air (400 mL min^{-1}); Column pressure: 11.5 psi; Injection mode: Split; Injector temperature: 250°C; Detector temperature: 280°C; Column: HP-INNOWA and temperature program: 120°C (1 min) and increase of 8°C/min up to 210°C (55 min).

Physico-chemical characterization: The moisture, color, density, acidity value, iodine value, saponification value and viscosity of the oils were determined according to AOCS methods (1994). The rheological behavior of each sample was evaluated (rheometer Brookfield, LV-DVII) at room temperature (25°C), using different shear rates. Once more the parameter values obtained by conventional methods are the mean results of three determinations for each oil sample.

Thermal analysis: The TG/DTG curves were obtained with the purpose of studying the thermal stability and obtaining the moisture and ash contents of the faveleira seed derivatives. It was used a thermobalance (Shimadzu, TGA-50), under air atmosphere (30 mL min^{-1}), using an alumina crucible, in non-isothermal conditions. The TG/DTG curves were obtained using a sample mass of 10.0±0.5 mg, heating rate of 10°Cmin^{-1}, at the 25-800°C temperature range.

The DSC curves were determined with the objective of studying the enthalpic transitions regarding the thermal decomposition of the faveleira seed derivatives, under nitrogen atmosphere (50 mL min^{-1}). A differential scanning calorimeter (Shimadzu, DSC-50) was employed, operating at the temperature range from room temperature up to 500°C, with a heating rate of 10°$Cmin^{-1}$. From the DSC data, were determined the specific heat capacities of the faveleira seed. Such DSC data were obtained from DSC curves performed both for the investigated samples and for alumina, the reference material.

RESULTS AND DISCUSSION

Chemical analysis: In terms of oil yield, it should be stressed that it varies between 35 and 50 weight percent of the whole seed. The chemical composition of the fatty acids present in the faveleira seed oil is listed in the Table 1.

The faveleira seed oil is highly similar to other edible vegetable oil (Santos *et al*., 2002) regarding the their fatty acids composition, e.g., the predominance of linoleic acid.

Physico-chemical analysis: The moisture content, acidity value, saponification value, color, density and iodine value of the faveleira oil, obtained by conventional methods, are listed in Table 2. The faveleira oil parameters are similar to those reported by other authors (Santos *et al*., 2002; 2004), mainly for the moisture and acidity contents. This oil has a high potential of achieving the required standards for human consumption as edible oil, due to their low moisture and low acidity and high saponification value.

In the refining process, the faveleira seed oil presents some advantageous features, for instance, its low free acidity (within the range admitted in the edible vegetable oil standard) and the absence of need of clarification. It presents a yellow color, color value of 1.0 desirable for the edible vegetable oil. Such oil also displays a Newtonian rheological behavior and it can easily be extracted in a laboratory.

The aroma and the flavor encourage the use as edible oil. After been used for frying, it did not cause smoke formation and maintained the food without any change in the aroma and flavor. After eight months of storage, the faveleira seed oil was shown to keep its perfect conservation conditions and it did not present rancidity, maintained unchanged its organoleptic quality.

The aforementioned faveleira seed oil advantages of high percentage of fatty materials, easy laboratory extraction, color, acidity, conservation and aroma and flavor, coupled to the potential use of the faveleira seed flour as a human food supply, due to its high protein contents, encourage a detailed study on the feasibility of the industrial faveleira seed processing.

Table 1: Fatty acid composition for the faveleira seed oil

Fatty acids	Composition (%)
Palmitic acid	22.0
Linoleic acid	41.6
Stearic acid	30.5
Myristic acid	1.3
Oleic acid	0.8
Saturated	53.8
Unsaturated	42.4
Total	96.2

Table 2: Physical and chemical parameters of the faveleira seed oil

Parameters	Results
Moisture (%)	0.452
Color	1.0
Density (g cm^{-3})	0.9125
Viscosity (mPa.s)	44.0
Saponification value (mg KOH g^{-1})	280.73
Acidity value (mg KOH g^{-1})	0.108
Iodine value (g I 100 g^{-1})	110.00

Table 3: Thermogravimetric data of the faveleira derivatives

Faveleira seed derivatives	1st step		2nd step		3rd step	
	T_p (°C)	%W	T_p (°C)	%W	T_p (°C)	%W
Oil-nitrogen	385.2	59.5	446.0	30.9	547.9	9.5
Oil-air	349.3	36.5	417.1	50.7	494.0	12.6

*T_p = peak temperature and %W = weight loss

Thermal analysis: The thermal decomposition behavior of the faveleira seed derivatives varies according to the type of the derivative. The thermogravimetric behavior of the faveleira seed oil (Fig. 1) displays three decomposition steps between 220-550°C, indicating a high stability, when compared with other edible vegetable oils (Santos *et al*., 2002; 2004).

The thermogravimetric profile of the faveleira flour samples showed one dehydration (water loss) step between 25-120°C and two thermal decomposition steps, related to the loss of their constituents at the 180-680°C range, of 69.3 and 21.7% mass loss, respectively (Fig. 2). The remaining residue (ash) at 800°C is roughly of 4%.

Table 3 contains the TG/DTG data of the analyzed samples.

The faveleira seed oil presented three thermal decomposition steps between 90 and 500°C (Table 4), indicating high thermal and oxidative stabilities, when compared with other edible vegetable oils (Santos *et al*., 2002). The oil sample presented an exothermic event with a peak temperature of 115°C, corresponding to its oxidation. The other two events correspond to the decomposition of its constituents. In air the first step 180-372, peak 319. Second step, 375-447, peak 415. Three step 449-553, peak 490. Oxidation results.

The DSC curves of the faveleira seed derivatives presented different profiles, in which can be observed endothermic transitions, (Fig. 3 and 4), corresponding to the decomposition of their principal constituents (water, lipids, carbohydrates and proteins).

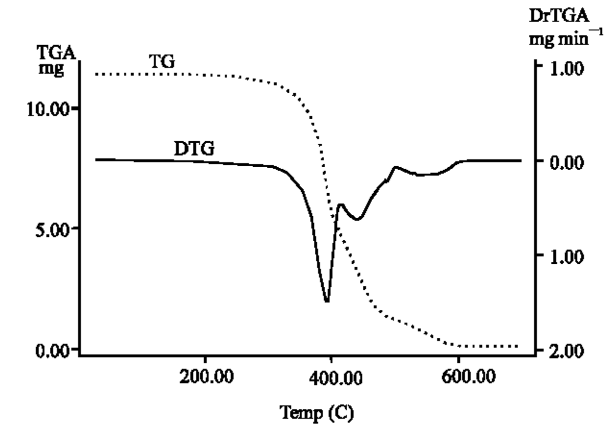

Fig. 1: TG/DTG curves of the faveleira seed oil under nitrogen atmosphere

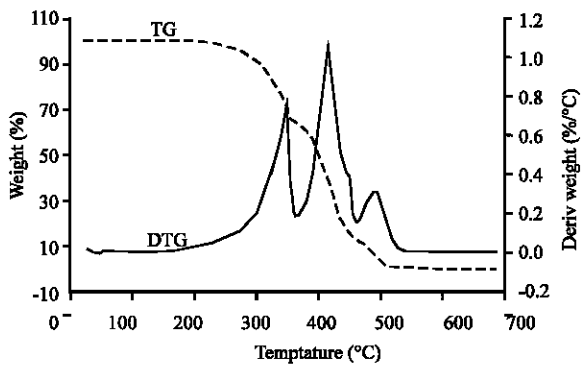

Fig. 2: TG/DTG curves of the faveleira seed oil under air atmosphere

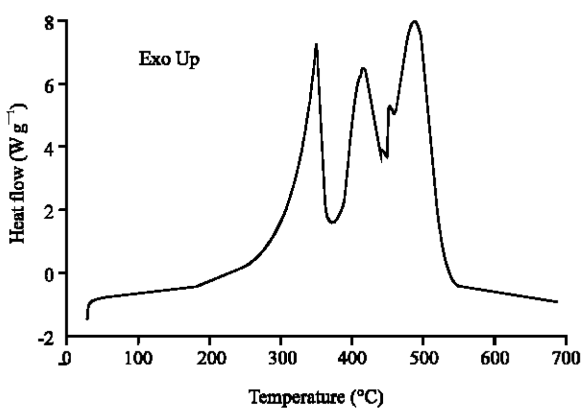

Fig. 3: DSC curves of the faveleira seed oil under air atmosphere

From the total integration of DSC curves for the thermal decomposition process of the faveleira seed derivatives at the 25-500°C range, can be estimated their mean calorific values (cal g^{-1}). The values obtained were: Oil

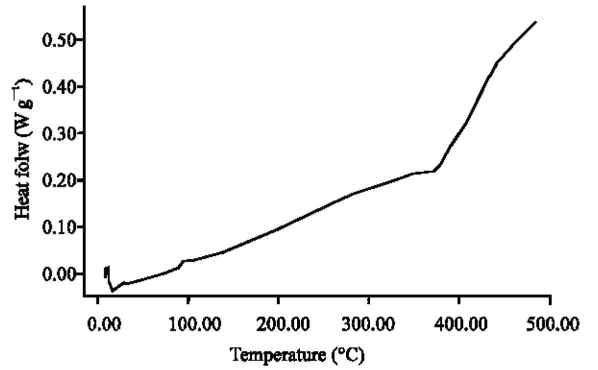

Fig. 4: DSC curves of the faveleira seed oil under nitrogen atmosphere

Table 4: Molar decomposition enthalpy (ΔH_DJ/g°C) obtained by DSC

Derivatives	1st step	2nd step	3rd step
Oil - Nitrogen	0.71	0.05	12.80
Oil - Air	1122.0	704.1	1425.1

Table 5: Specific heat capacities of the faveleira seed derivatives

Faveleira seed derivatives	Cp (J/g°C) 40°C	60°C	80°C	100°C	120°C
Oil	1.625	1.689	1.702	1.806	1.834

(75.6), These values are similar to the ones of other foods utilized for human use Lima, 1986, Table 4 contains the values of the decomposition enthalpy for the samples investigated by DSC.

Heat Capacity (C_p): The specific heat capacities of liquid phase (oil) and solid phase (almond and flour) samples were determined according to the previously described method. The specific heat capacity values of the faveleira seed derivatives are listed in Table 5.

For most of the samples, the specific heat capacity values did not substantially vary as a function of temperature.

CONCLUSION

The study of the thermal analytical properties of the faveleira seed derivatives contributes to a better understanding of the probable chemical changes of these materials when exposed to high temperatures.

The faveleira seed oil advantages of high percentage of fatty materials, easy laboratory extraction, color, acidity, conservation and aroma and flavor, coupled to the potential use of the faveleira seed flour as a human food supply, due to its high protein contents, encourage a detailed study on the feasibility of the industrial faveleira seed processing. Further studies are needed to investigate the presence of toxins in the faveleira seed derivatives.

According to the herein described results, the faveleira seed derivatives present thermodynamic properties similar to the ones of other foods utilized for human use, as well as an acceptable calorific value. The present study contributes to the incorporation of the faveleira to the economy of the semi-arid region of Northeastern Brazil, for the production of flour for human use, of almond for the production of edible vegetable oil and for the production of other derivatives for animal use.

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