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Fractional characterisation of jatropha, neem, moringa, trisperma, castor and candlenut seeds as potential feedstocks for biodiesel production in Cuba

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ABSTRACT

A preliminary investigation on the suitability of various non-edible oil seeds for the integral utilisation of their fractions for production of biodiesel and other products was carried out. The oil seeds considered were jatropha (*Jatropha curcas*), neem (*Azadirachta indica*), moringa (*Moringa oleifera*), trisperma (*Aleurites trisperma*), castor beans (*Ricinus communis*) and candlenut (*Aleurites moluccana*). The highest oil content (62.0% (w/w)) was found in trisperma seeds, but the use of that oil for biodiesel production is restricted by its high content of polyunsaturated fatty acids. The oils of castor beans and moringa contained 86.0% of ricinoleic acid and 70.6% of oleic acid, respectively, while in the oils from the other seeds no predominance of any acid was observed. According to the oil yield and to the fatty acid composition of the oil, jatropha was identified as the most promising oil seed for biodiesel production in Cuba. All the press cakes were rich in protein, the highest content (68.6%) being detected in moringa cake. The investigation revealed that the husks of neem and moringa can be considered potential substrates for ethanol production due to their high cellulose content (approximately 30%). A high concentration (4.3%) of acetyl groups was found in neem husks, what is favourable for the hydrolytic conversion of polysaccharides to simple sugars. A high protein content (15.2%) was detected in moringa husks, which is a positive feature for lowering the cost of nutrient supplementation in ethanolic fermentation.

1. Introduction

There is a growing interest in using biodiesel as an alternative transportation fuel, since it is made from renewable biological sources, is biodegradable and nontoxic, and has low emission profiles [1,2]. Biodiesel is produced by transesterification of vegetable oils or animal fats with methanol or ethanol. While important amounts of biodiesel are nowadays produced from edible sources, such as soyabean and sunflower oil, a challenge for biodiesel production is to use feedstocks that would

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not compete with human food [3]. In that direction, jatropha (*Jatropha curcas*), neem (*Azadirachta indica*), moringa (*Moringa oleifera*), trisperma (*Aleurites trisperma*), castor beans (*Ricinus communis*) and candlenut (*Aleurites moluccana*) have been identified among the most promising non-edible oil-bearing seeds for biodiesel production in Cuba.

During the biodiesel production several residues, such as press cakes, husks and glycerol are generated. Press cakes, the residues remaining after mechanical or solvent extraction of the oils from the seed kernels, can be utilised as raw materials in different bioprocesses for the production of chemicals and value-added products such as amino acids, enzymes, vitamins, antibiotics and biopesticides [4,5]. However, those uses are restricted to edible oil cakes, which are recognised to have a high nutritional value, due to their high protein content [6]. Non-edible oil cakes have been less investigated, and their uses are limited to organic fertilisers and biogas production [7].

The husks, generated during dehusking of the seeds for obtaining the kernels, generally are of low economic value, and they are mainly disposed or burnt. In some cases, the husks are used as solid fuel or as raw materials for activated charcoal production [8,9].

The integral utilisation, according to the biorefinery concept, of all the fractions generated in the biodiesel production is a requirement for the economy and the sustainability of the process, and for the rational exploitation of the raw materials. For elucidating potential uses of non-edible oil cakes and husks it is necessary to investigate their chemical composition. In this work, a systematic characterisation, including the analysis of the composition of the main fractions, of six different non-edible oil-bearing species was performed.

2. Materials and methods

2.1. Materials

Fresh seeds of moringa (*M. oleifera*), neem (*A. indica*) and castor beans (*R. communis*) were provided by Las Tunas Station of Pastures and Forages (20°57′ N, 76°57′ W, Las Tunas, Cuba). Jatropha (*J. curcas*), trisperma (*A. trisperma*), and candlenut (*A. moluccana*) were provided by Sancti Spiritus Station of Pastures and Forages (21°59′ N, 79°14′ W, Sancti Spiritus, Cuba). All the seeds were selected from manually-collected ripened fruits, whose exocarp and mesocarp were removed. The fruits were harvested in December 2006 in young plantations (3–4 years old). The seeds were air dried to 10–15% moisture content, stored in plastic bags and transported by air to the University of Vigo, Spain.

The characterisation of the seeds was carried out according to the scheme shown in Fig. 1. The seeds were manually dehusked, and the husks were dried at 50 °C for 24 h, milled to 1-mm particle size, sieved to remove the rejects, and stored in plastic bags at room temperature until analysis.

2.2. Oil extraction

The oil was squeezed out from the kernels with a hand-operated pneumatic press (Enerpac VLP-106P142, Hydraulic Technology Worldwide, USA). A pressure of 8.8 MPa was applied during 5 min to each portion of the kernels. Fresh oil was transferred to Eppendorf tubes and stored at 4 °C until analysis. In the case of castor beans, the oil was squeezed out directly from the seeds, since pressing of the kernels was impracticable in the available facility. The press cakes were defatted overnight at 35 °C in a rotary shaker, using hexane at a liquid-to-solid ratio of 15:1 g g^{-1}. The defatted press cakes were recovered by vacuum filtration and dried at 40 °C for 24 h. Dry defatted cakes were ground in a coffee grinder to 1-mm particle size, and stored at 4 °C until use. The total oil content was determined gravimetrically.

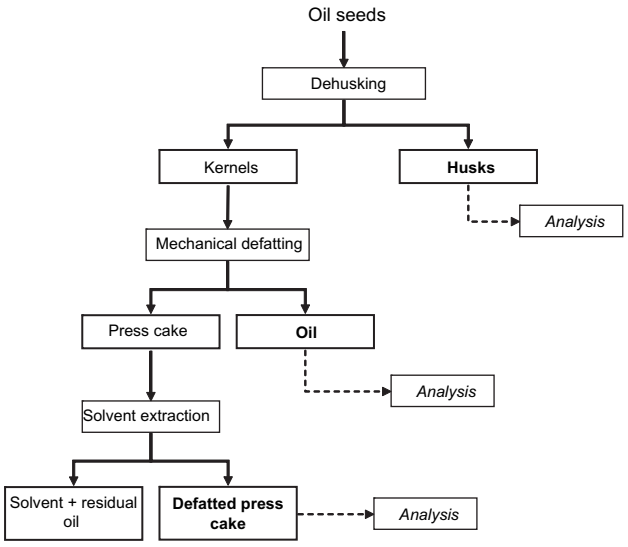

Fig. 1 – Scheme of the analytical procedure followed for characterisation of oil seeds.

2.3. Analytical methods

Moisture and ash were determined according to standard methods [10]. Extractives were determined gravimetrically after Soxhlet extraction with 96% (v/v) ethanol during 24 h. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined using the detergent methods [11].

Elemental nitrogen determination was carried out by means of a Finnigan Flash EA 1112 analyzer (Thermo Fisher Scientific, Waltham, USA) using 130 and 100 mL min^{-1} of He and O_2 and an oven temperature of 50 °C. All determinations were made in triplicate. The protein content was obtained by multiplying the elemental N content by the universal factor 6.25.

Quantitative acid hydrolysis with 72% sulfuric acid according to standard methods [12,13] was carried out, followed by HPLC analysis of the hydrolysates, to determine polysaccharide composition. Glucose, xylose, arabinose and acetic acid concentrations in hydrolysates were determined by HPLC using a Hewlett Packard chromatograph fitted with a refractive index detector (temperature, 40 °C). Other analysis conditions were: column, ION-300 (Transgenomic, Inc., USA); mobile phase, 3 mM H_2SO_4; flow, 0.4 mL min^{-1}.