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Evaluation of alternative solvents for improvement of oil extraction from rapeseeds

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ABSTRACT

This present study was designed to evaluate the performances of five alternative solvents (alcohols: ethanol, isopropanol and terpenes: D-limonene, α-pinene, *p*-cymene) compared to *n*-hexane in rapeseed oil extraction. The extracted oils were quantitatively and qualitatively analyzed to compare the solvents' performances in terms of kinetics, fatty acid compositions, lipid yields, and classes. Moreover, micronutrients in extracted oils were also respectively quantified by high-performance liquid chromatography (HPLC) and gas chromatography (GC). In addition, the interactions between alternative solvents and rapeseed oil have been theoretically studied with the Hansen solubility methodology to get a better comprehension of dissolving mechanisms. The results indicated that *p*-cymene could be the most promising solvent for *n*-hexane substitution with higher lipid yield and good selectivity, despite the micronutrient contents were relatively low.

RÉSUMÉ

L'objectif de cette étude vise à évaluer les performances de cinq solvants alternatifs (deux alcools : éthanol, isopropanol, et les terpènes, D-limonène, α-pinène, *p*-cymène) par rapport au *n*-hexane pour l'extraction de l'huile de colza. Les huiles extraites à l'aide de ces différents solvants ont été analysées quantitativement et qualitativement afin de comparer à la fois les cinétiques d'extraction, la composition en acides gras de ces dernières, ainsi que les rendements lipidiques. En outre, les micronutriments présents dans les huiles extraites ont été également quantifiés à la fois par chromatographie en phase liquide à haute performance (HPLC) et par chromatographie en phase gazeuse (CPG). De plus, les interactions entre les solvants alternatifs et l'huile de colza ont été étudiées théoriquement à l'aide de la méthodologie de solubilité de Hansen afin d'essayer de mettre en avant une meilleure compréhension des mécanismes de dissolution. Les résultats indiquent que le *p*-cymène pourrait être le solvant le plus prometteur pour la substitution du *n*-hexane, avec un rendement lipidique élevé et une bonne sélectivité, malgré une teneur en micronutriments relativement faibles.

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1. Introduction

Over the last five decades, the industrial oil extraction process has changed little, though there have been several technical developments with regard to its optimization and a better control. The conventional process procedure involves three main successive unit operations, as shown in Fig. 1. Seed preparation includes cleaning, pre-heating (50–80 °C), crushing and cooking (prepared seed flakes from previous steps undergo indirect steaming at 90–110 °C, which causes a 1–3% loss of water content). Mechanical extraction makes a press cake, also called "oilcake", containing 16–24% of oil after continuous pressing, which depends on the variety of the treated seeds. The following solvent extraction from ground oilcakes is achieved by a counter-flow current extraction using *n*-hexane as a solvent. The extraction meal is desolventized by desorption and evaporation of hexane through direct and indirect steam injection. The oils are recovered by distillation of miscella, which allows evaporation of volatile solvents by vacuum steam stripping.

The conventional process utilizes only mechanical extraction (pre-press yields about 60% of oil) or solvent extraction, or even combines both of them [1]. In order to become edible, the crude vegetable oil, a mixture of pressed and extracted oil, must undergo further refining processes for elimination of impurities and contaminants, in order to guarantee physicochemical and organoleptic properties that fitted to the requirements of downstream users. The processing methods developed over the years have been designed to reduce operating costs, to maximize the oil yields and solvent recovery, as well as the preservation of crude oil quality by avoiding enzymatic and oxidative degradation. Some influencing factors in extraction processes have been previously studied, e.g., the nature of solvents [2], the particle size [3] and extraction conditions such as temperature, pressure, etc. [4]. Above

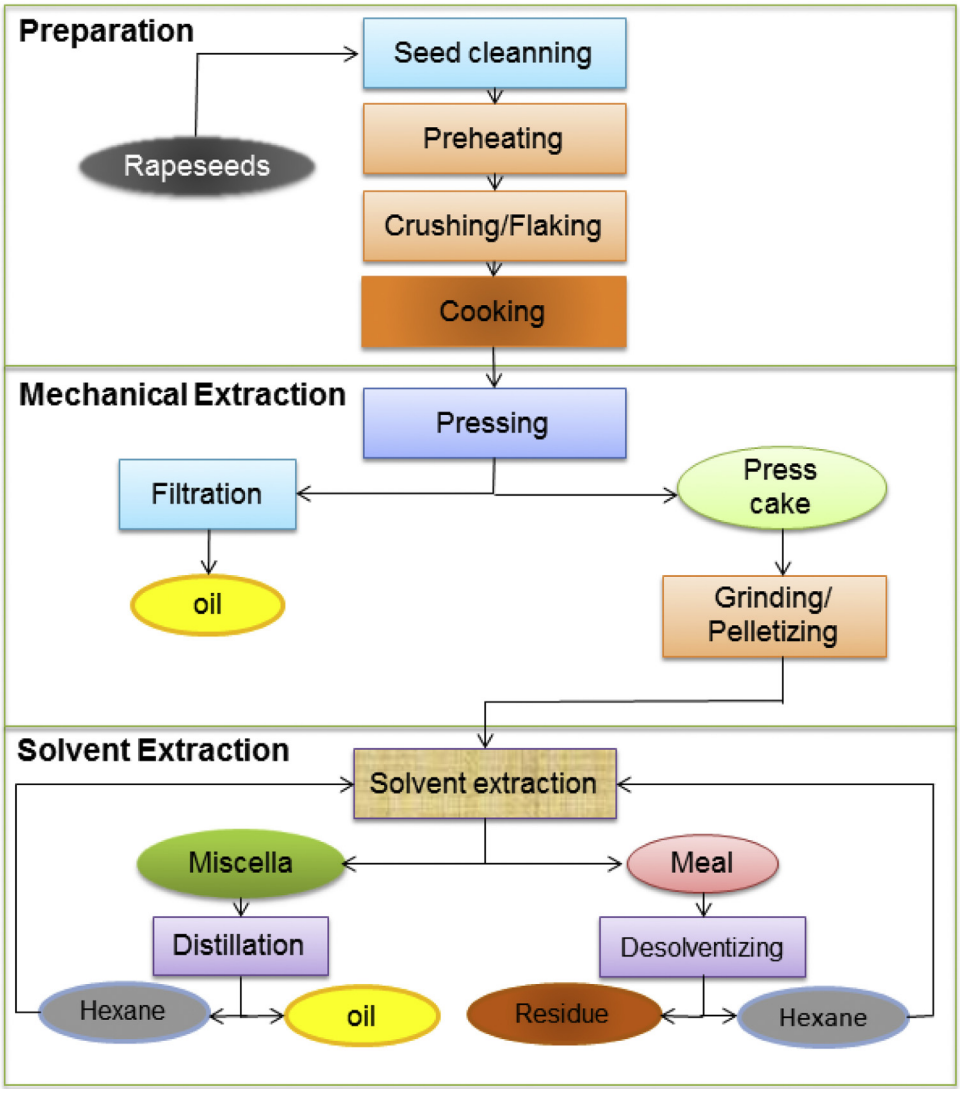

Fig. 1. Conventional processing procedures for rapeseed oil extraction. Color online.