A comparison of three different methods for the extraction of sesame oil(Sesamum indicum L.)

Mehdi Louaer[1], Ahmed Zermane[1,2] ,OuassilaLarkeche[1],Colette Besombes[3], Karim Allaf[3], Abdeslam Hassan Meniai[1]

1: Laboratory of Environmental process engineering, University of Constantine3, Algeria
2: University Larbi Ben M'Hidi, Oum El Bouaghi, Algeria
3: Laboratory of Engineering Science for Environment,University of La Rochelle, France

Abstract

The main objective of the present work wasto investigate the extraction of sesame seed (Sesamun indicum L.) oil using three different methods (Cold pressing CP, Cold pressing coupled to supercritical fluid extraction CP-SFE and Cold pressing coupled to organic solvent extraction CP-OSE). The obtained extraction yield values were 9.19, 57.15 and 59.52% for CP, CP-SFE and CP-OSE, respectively. CP-SFE and CP-OSE were by far the most promising extraction methods. However considering other parameters, CP-SFE can be the preferred methodleading tooils with high quality, process residues with minimum remained oil content and no further costs induced by the organic solvent recovery for the case of CP-OSE.

Keywords:*Sesameoil; Cold pressing; Supercritical fluid extraction; Organic solvent extraction*

I. Introduction

Sesame (Sesamumindicum L.) plant is an important and ancient oil supplier which is cultivated extensively in several countries like India, China, Sudan, Burma, Nigeria, Egypt etc., considered as the major producers with up to 60% of the total world production[1]. In 2003 the annual production was 760,000 million tons, the 12th largest used vegetable oil in the world exceeding olive and sunflower oils productions [2]. Sesame seeds have high economical and nutritional value mainly due to their high oil content (45–60%) [3]. The oil is mainly used for edible purposes, as a salad dressing, to produce shortenings and margarine and also for cosmetic and pharmaceutical purposes[3–5].

Sesame oil is composed predominantly of mono- and di-unsaturated fatty acids (FA) where the major ones were oleic, linoleic, palmitic, and stearic acids, etc. with altogether about 96% of the total fatty acids content [1]. The unsaponifiable matter of sesame oil (up to 3% of the total oil content) is essentially made of tocopherols (400–700 mg/kg), free and esterified sterols, and a specific type of lignans namely sesamin, sesamolin, sesamol, and sesaminol with important biological properties which decreased the autoxidation of oil [6].

Extraction of sesame oil has known a significant development over the years comparatively to many conventional processes for vegetable oil extraction like those involving screw-pressing processes of sesame, after generally a seed roasting step that can increase oil recovery but may have deleterious effects on oil quality [3]. Mechanical pressing followed by an extraction using liquid organic solvents and a distillation for solvent recovery is one of the most common route traditionally used for sesame oil extraction [1]. An alternative process to minimize the use of liquid organic solvents and facilitate the solvent recovery is the use of supercritical fluids, mainly carbon dioxide. It permits the efficient removal of triglycerides from vegetable oils, with an easy separation of solvent, oil and process residues to obtain products totally free of solvent[7].

The objective of the present paper is to compare three experimental routes of sesame oil extraction: cold pressing (CP), cold pressing coupled to supercritical fluid extraction(CP-SFE) and cold pressing coupled to organic solvent extraction (CP-

OSE), in term of extraction yield, as shown in the following fig.1:

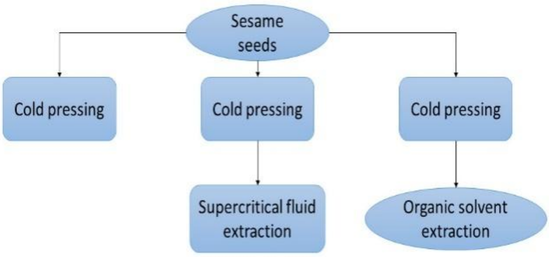

Figure 1. Protocol of the study

II. Materials and methods

A Raw materials and chemicals

Commercial sesame seeds used in this study were purchased from local market and supplied by (AL JAMEEL INTERNATIONAL, UAE), with 5% dry basis water content measured by drying in an oven at 105°c for 24 hours. The used carbon dioxide for oil extraction was of 99.5% purity and was supplied by SIDAL SPA Air liquid, Algeria. n-Hexane used in this study was purchased from Carlo Erba (Val de Reuil, France) with 99.99% purity.

B Cold pressing extraction (CP)

To obtain sesame seeds oil by CP, a single screw press machine (P500R, ANTONE FRIES, GERMANY) was used (Fig. 2). The press is made with high-quality, hardened tool steel with a capacity of 12-30 kg/h and Engine Speed of 5-95 rpm. For each run, 600g of sesame seeds samples were introduced into a metallic container, then were subjected to the press load with Engine speed of 75rpm. The resulting pressed cakes were transferred to the next stage of extraction using supercritical carbon dioxide and n-Hexane for solvent extraction.

Figure 2. Screw press machine

Fig.3 illustrates the sesame seed cake issued from CP extraction; the pressed cakes were valorized using SFE and OSE, the pressed cake (rich in fat) resulting from the pressing operation were subjected to carbon dioxide in its supercritical state on the one hand and hexane extraction (Randall technique) on the other hand

Figure 3. Sesameseed cake

C Supercritical fluid extraction (SFE)

SFE was performed in a dynamic pilot-plant (Separex 4343, type SF2) supplied by Separex (Champigneulles, FRANCE). It is mainly consisting of: (A) high pressure pump; (B) extraction reactor; (C) expansion system (D) separation system as shown in Fig. 4.

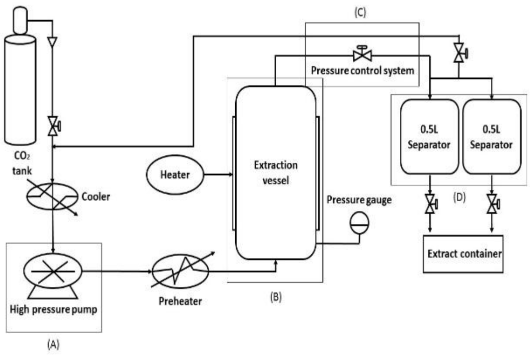

Figure 4. Schematic drawing of SFE pilot

Initially about 50g of pressed cake was placed in the extractor. Compressed carbon dioxide flew into the extractor and was electrically heated. The exiting carbon dioxide from the extractor passed into the separation system and was expanded using an expansion valve. Oil extracted was collected every 15 min and weighed immediately after collection. Extraction conditions were fixed according to the literature [7] and after preliminary experiments, extractions were carried out at temperature (T) of 50°C, pressure (P) of 250 bar and flow rate of 50g/min.

D Organic solvent extraction (OSE)

In order to assess the efficiency of coupling Cold pressing technique and solvent extraction, Randall apparatus shown in Fig.5 was used.

The Randall modification of the standard Soxhlet extraction reduces the time needed for extraction by submerging the sample portion by boiling solvent [8], dissolving fats, oils, pigments, and other soluble substances, known altogether as "crude fat. For this purpose, 5 g of pressed cake sesame seeds was placed in cellulose thimble (fig.5) then loaded to the apparatus. First, the thimbles were immersed in 60 ml of boiling hexane for 90 min before they were raised to rinse position for 60 min, the solvent was evaporated and recovered by condensation. The obtained crude fat was determined gravimetrically.

Figure 5.left: Randall apparatus; right : cellulose thimble

III. Results and discussions

The extraction yield was calculated as :

$$Yield(\%) = \frac{masse\ of extracted\ oil\ (g)}{masse\ of dry\ mater\ (g)} \times 100 \qquad (1)$$

A Oil extraction by pressing from sesame seeds

Oil extraction by CP is simpler, safer and contains fewer steps, compared to solvent extraction.

The screw pushes the seeds to a die located at the end of the cage. Under the effect of compression, a part of the seed oil is separated from the residual solid material and leaves in the back through the perforated sleeve. Sesame cake outflows at the press end. The performance of the press depends on the design of the screw and the size of the filter [9]. The flow pressure is strongly recommended by the diameter of outlet of the die (in our case, it was 8 mm). Fine particles in the expressed oil were separated by filtration and the filtrate and the cake were collected, weighed and stored at 4 °C. The oil extracted was filtered and measured. The oil content was gravimetrically determined and was about 9.19 % (Tab.1).

Table 1. Extraction results for CP

Cold pressing	Masse of sesame (g)	Moister content (%)	Engine speed (tr/min)	Number of passes	CP Yield (%)
Sesame seeds	600	5	75	1	9.19

B Coupling CP extraction to SFE

The results of oil extraction by SFE from pressed-cake sesame seed was given in Tab. 2.

Table 2. Extraction results for CP-SFE

SFE	Masse of cake (g)	P (Bar)	T (°c)	Flow rate (g/min)	Yield (%)	CP-SFE Yield (%)
Pressed cake	50	250	50	50	47.96	57.15

A high difference in oil recovery between the cold pressing and the CP-SFE was observed. CP-SFE showed a yield value of 57.15%, 6 times higher to yield obtained by CP (9.19%). SFE of oil from the pressed cake showed that the remained oil content after the cold pressing stage was about 84%, this made the second stage of extraction very important in term of valorization of the pressed cake. The high solubility in SC-CO_2 and the great accessibility of the oil after the cold pressing stage provided high extraction yields.

C Coupling CP extraction to OSE

Experimental conditions are shown in tab. 3:

Table 3. Extraction results for CP-OSE

OSE	Masse of cake (g)	Volume of hexane (ml)	Immersion time (min)	Washing time (min)	Evaporation time (min)	Yield (%)	CP-OSE Yield (%)
Pressed cake	5	60	90	60	40	50.3	59.5

As shown in Fig. 6, the oil yield recovery with CP-OSE is much higher than that obtained by CP. It should also be noted that the obtained value of the CP-SFE extraction yield of 57.15% was slightly lower than 59.52% obtained for a performed CP-OSE extraction. However as it is known, the use of organic solvents for extracting various components from natural productshas huge limitationsdue to some of their properties like the toxicity, the flammability and the waste quantities. Therefore, the use of supercritical CO_2 extraction has many advantages such as:• Extracts and spent biomass free of solvent residues. • Extraction time much shorter. • Mild operating temperature ensuring product stability and quality. • Supercritical CO2 is universally accepted as a “friendly” fluid towards the environment. • Possibility of a full recycling of the supercritical CO2. • Product recovery through a simple pressure reduction. • Low operating costs due to efficient compression energy.

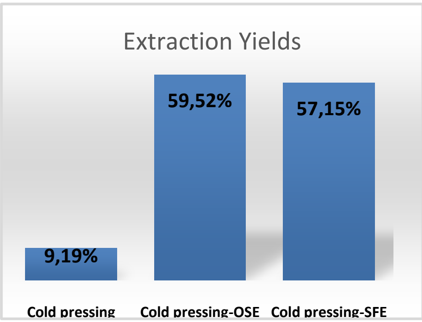

Figure 6. Extraction yields

IV. n clusion

Sesame as a valued oil seed showed to have several industrial applications. It is therefore important to fully develop industrial processes to extract their oil content in a substantial quantity to meet the current demands. This work investigated the extraction of the sesame seeds using CP, CP-SFE and CP-OSE. The results showed that CP-OSE gave a high yield comparing to CP but provided nearly similar yield to that obtained by using CP-SFE. However, CP-SFE has many advantages in terms of extract purity and solvent toxicity comparing to CP-OSE.

References:

[1] A. Elkhaleefa, I. Shigidi, Optimization of Sesame Oil Extraction Process Conditions, Adv. Chem. Eng. Sci. 05 (2015) 305–310.

[2] M. Rostami, V. Farzaneh, A. Boujmehrani, M. Mohammadi, H. Bakhshabadi, Optimizing the extraction process of sesame seed’s oil using response surface method on the industrial scale, Ind. Crops Prod. 58 (2014) 160–165.

[3] M.L. Martínez, M.G. Bordón, R.L. Lallana, P.D. Ribotta, D.M. Maestri, Optimization of Sesame Oil Extraction by Screw-Pressing at Low Temperature, Food Bioprocess Technol. 10 (2017) 1113–1121.

[4] A.. Warra, Sesame (Sesamum Indicum L .) Seed Oil Methods of Extraction and Its Prospects in Cosmetic Industry : a Review, Bayero J. Pure Appl. Sci. 4 (2011) 164–168.

[5] P. Budowski, K.S. Markley, The chemical and physiological properties of sesame oil, Chem. Rev. 48 (1951) 125–151.

[6] R. Tir, P.C. Dutta, A.Y. Badjah-Hadj-Ahmed, Effect of the extraction solvent polarity on the sesame seeds oil composition, Eur. J. Lipid Sci. Technol. 114 (2012) 1427–1438.

[7] M.P. Corso, M.R. Fagundes-Klen, E.A. Silva, L. Cardozo Filho, J.N. Santos, L.S. Freitas, et al., Extraction of sesame seed (Sesamun indicum L.) oil using compressed propane and supercritical carbon dioxide, J. Supercrit. Fluids. 52 (2010) 56–61.

[8] S. Moldoveanu, V. David, Solvent Extraction, 2015.

[9] N. Rombaut, Etude comparative de trois procédés d’extraction d’huile : aspects qualitatifs et quantitatifs : application aux graines de lin et aux pépins de raisin, 2013.