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Development of New Economical and Sustainable Processes for the Extraction of Essential Oils from Aromatic and Medicinal Plants

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ABSTRACT

In this study, biomass residues from the aromatic and medicinal oil extraction industries were used as fuel for the production of steam necessary for the extraction of essential oils (EO) by hydrodistillation from a plant around the Mediterranean, *Daucus carota* L. The results obtained in terms of yield and extraction time were compared with those obtained by the classical method of hydrodistillation (HD) using electric heating. Several advantages with hydrodistillation in the presence of biomass as an energy source (BEHD) have been observed: faster kinetics and higher efficiency with similar yields: 1.03% and an extraction time of 30 min against 180 min for classic hydrodistillation. The chemical composition of the EO was determined by gas chromatography (GC/FID) and gas chromatography coupled with apolar column mass spectrometry (CG/MS). The antimicrobial activity of the EO was evaluated against four bacteria and one pathogenic yeast, using the disc-diffusion method and minimal inhibitory concentration (MIC), whereas, the antioxidant activity of the EO was evaluated using the DPPH test.

Keywords: waste valorization, aromatic and medicinal plants, extraction, essential oil, Biomass energy, hydrodistillation.

1. Introduction

The cosmetic, pharmaceutical, food and perfume industries, like other economic sectors, are encouraged to favor energy-saving practices through the development of innovative and efficient technologies and promote the use of alternative energy sources so that they are economical and environmentally friendly [1]. Agro- and industrial processes that utilizes aromatic and medicinal plants generates various kinds of residues like residual biomasses from distillation of aromatic plant and non-utilized parts of medicinal plant [2]. These residual biomasses cannot be considered as waste as these can actually be recycled and converted into value added products [3]. Nevertheless, the energy potential of this waste is interesting and their integration as energy inputs in industrial processes has considerable economic and environmental stakes [4]. These wastes can be used as fuel for production of steam necessary for the extraction of essential oils. It is in this perspective of seeking energy gain with a view to improving the energy efficiency of extraction processes and respect for the environment, which is part of this research work.

2. Experimental

2.1 Essential oils extraction Procedures

The extraction of the EO from *Daucus carota* was performed by hydrodistillation using conventional technique (HD) and hydrodistillation using biomass residues as an energy source (BEHD).

2.2 Conventional Technique: Hydrodistillation (HD):

A Clevenger-type apparatus was adopted for conventional method (HD). The plant material, weighed and washed, is put in a 2L balloon then covered with water, it is then brought to the boil using a heating electric, the water vapor entrains the EO which is condensed on a cold surface. We collected the distillate (EO + water) in a separatory funnel. At the end of each experiment, the essential oil obtained by decantation is



recovered, and dried over anhydrous sodium sulfate (Na_2SO_4) to remove all traces of water. It is then kept in the refrigerator, in brown glass bottles in order to avoid any degradation of the EO.

2.3 Hydrodistillation using biomass residues as an energy source (BEHD):

BEHD was carried out in a similar manner as HD conventional. However, in the BEHD method, the steam needed to extract the essential oil from the *Daucus carota* plant was produced by using the biomass waste as a fuel (heat source). Combustion can be characterized as a chemical reaction strongly exothermic irreversible between a fuel and an oxidizer (or oxidant).

3. Results and Discussion

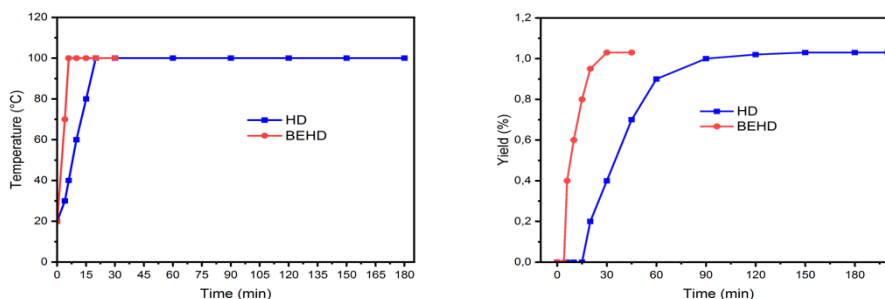


Figure 1: Extraction kinetics and extraction yield

Table I: Antimicrobial activity of *Daucus carota* EO

Microorganisms tested	Inhibition zone diameters (mm ^a ± SD ^b)	
	EO-HD	EO-BEHD
Gram-positive bacteria		
<i>Staphylococcus aureus</i> ATCC 6538	17 ± 2,0	22 ± 2,1
<i>Bacillus subtilis</i> ATCC 6633	16 ± 1,4	19 ± 1,2
Gram-negative bacteria		
<i>Escherichia coli</i> ATCC 25922	10 ± 1,3	14 ± 0,7
<i>Pseudomonas aeruginosa</i> ATCC 14028	8 ± 1,9	17 ± 1,4
Yeast		
<i>Candida albicans</i> ATCC 10231	20 ± 1,1	23 ± 1,1

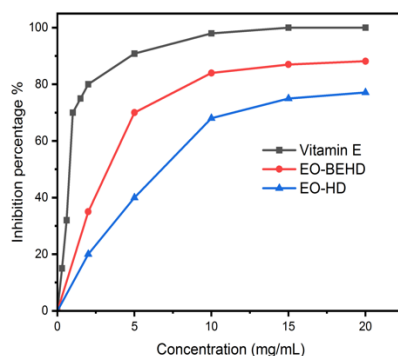


Figure 2: antioxidant activity of EO

4. Conclusion

Reducing the cost of extracting essential oil from *Daucus carota* using biomass as fuel, is highlighted in

terms of time required and energy consumed. The results show that the combustion of biomass rejected by an essential oil production is able to provide the heat necessary for the extraction process. The use of biomass residues for steam production, can make a major contribution to improving the energy efficiency of the extraction processes. Indeed, beyond environmental benefits, use of biomass as an energy source also has several economic advantages since it makes it possible to reuse waste, avoid management costs and save fossil fuels.

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