Antibacterial activity of aqueous solutions of essential oils as an indicator for their content

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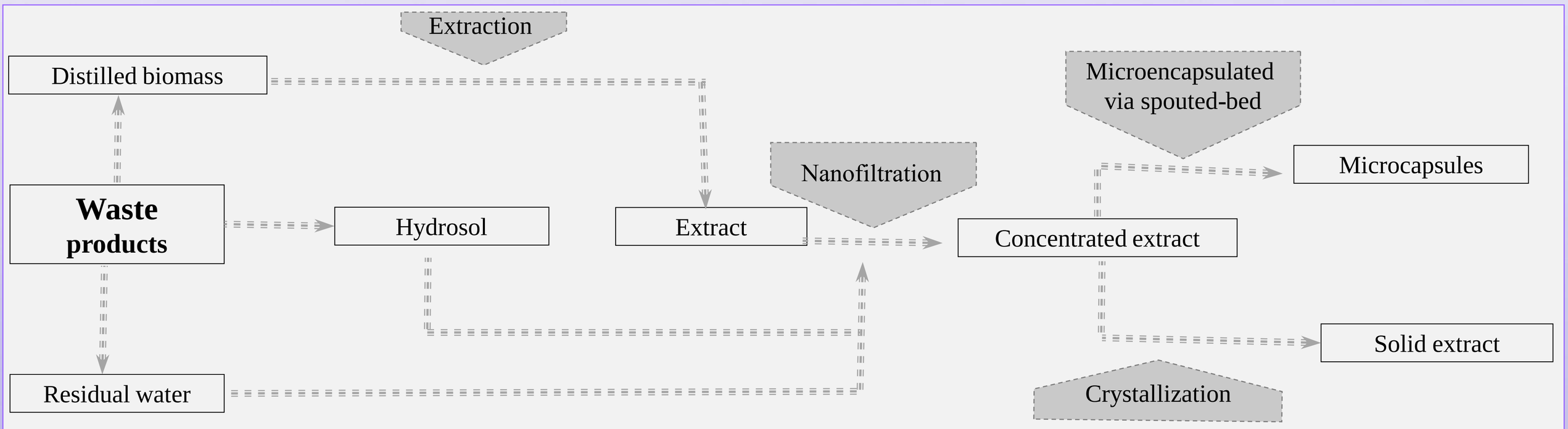
Introduction

According to market forecasts, annual consumption of essential oils is growing steadily, reaching 403 thousand tonnes in 2025. The steam distillation of the plant materials to produce essential oils generates vast amounts of aqueous fractions as by-products. Certain amounts of essential oils remain dissolved in these fractions, predetermining their biological activity. These by-products often are discarded into the environment and they have a negative impact on the ecological balance.
The aim of this study is to examine the biological activity of essential oils and their aqueous fractions and to evaluate the possibilities for complex utilization of the waste products gained by the essential oil industry.



Scheme 1. New opportunities for valorisation of the waste streams from the steam distillation of essential oils, using nanomembrane separation

Results

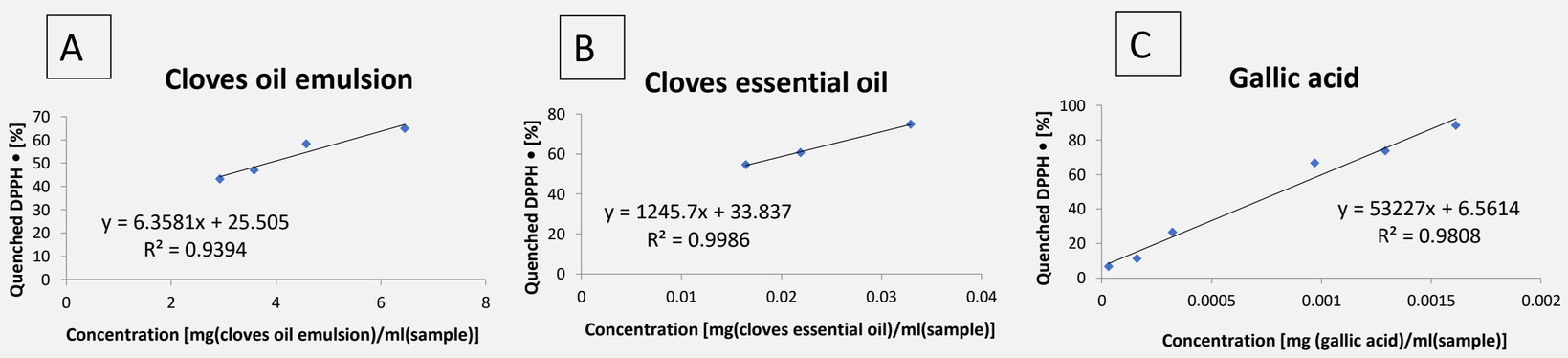


Figure 1. Experimental data and curve fitting for DPPH• quenching for 60 min by cloves oil emulsion (A), cloves essential oil (B) and gallic acid (C) versus concentration of antioxidant in the samples.

The antioxidant power was also characterized by the EC_{50} value: EC_{50} (A) = 3.852566 mg(cloves oil emulsion)/ml(sample); EC_{50} (B) = 0.012975 mg(cloves essential oil)/ml(sample); EC_{50} (C) = 0.000816 mg(gallic acid)/ml(sample)

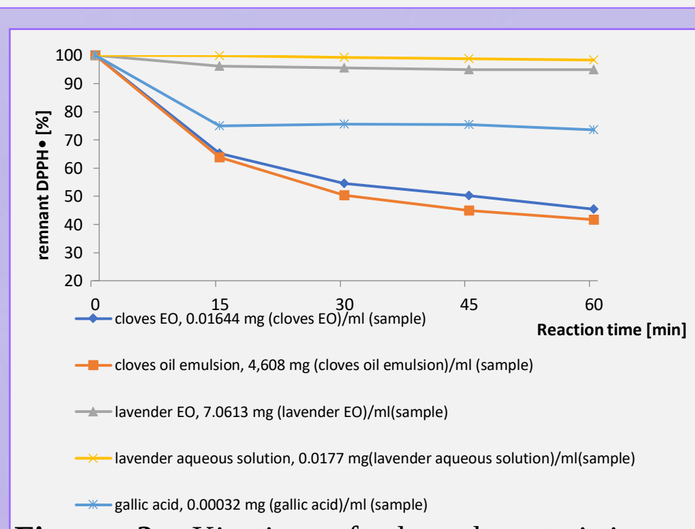


Figure 2. Kinetics of the characteristic radical scavenging reaction of lavender and clove essential oil (EO), lavender aqueous solution, cloves oil emulsion and gallic acid with DPPH•

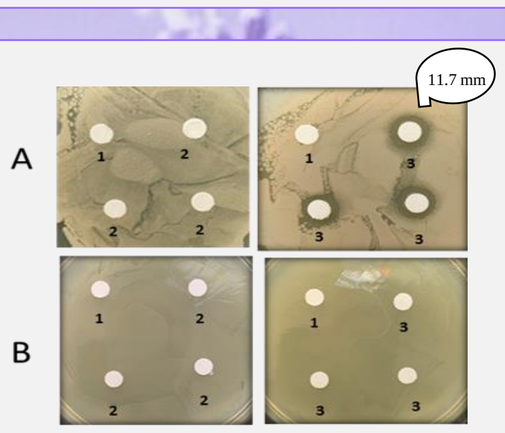


Figure 3. Antibacterial test results of lavender samples against *B. subtilis* 3562 (row A) and *E. coli* K12 (row B) – control (1), lavender aqueous solution (2), lavender essential oil (3)

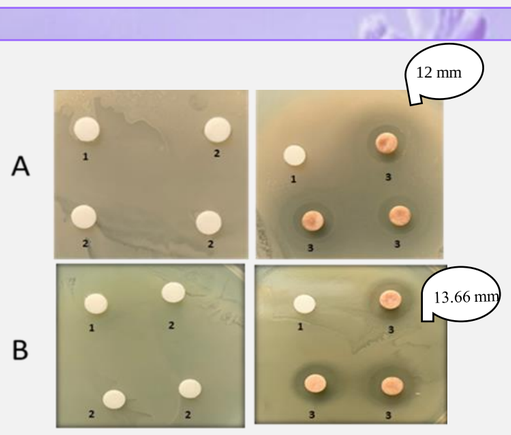


Figure 4. Antibacterial test results of cloves samples against *B. subtilis* 3562 (row A) and *E. coli* K12 (row B) – control (1), cloves oil emulsion (2), cloves essential oil (3)

Table 1. Microdilution test results

Bacterial strain	Lavender aqueous solution						Cloves oil emulsion											
	Concentration [mg(lavender AS*)/ml (sample)]						Concentration [mg(cloves OE**)/ml(sample)]											
	0.37		0.28		0.25		2.33		1.94		1.56		0.37		0.28		0.25	
	6 h	24 h	6 h	24 h	6 h	24 h	6 h	24 h	6 h	24 h	6 h	24 h	6h	24 h	6 h	24 h	6 h	24 h
B. subtilis 3562	Growth reduction [%]																	
	0	0	0	0	0	0	96	96	78	49	42	40	30	27	30	11	28	7
E. coli K12	0	32	0	25	0	25	98	94	97	81	78	76	29	0	25	0	11	0

*AS – aqueous solution; **OE – oil emulsion

Conclusions

- Cloves essential oil and its oil-in-water emulsion have relatively higher biological activity compared to lavender essential oil and its aqueous solution.
- The microdilution assay indicated more prominent inhibition activity against *E. coli* K12 strain in comparison to *B. subtilis* 3562 for both oil-water mixtures.
- The disk diffusion test confirmed the greater inhibition of the *E. coli* K12 growth with cloves oil while lavender oil inhibited only the Gram-positive strain.
- Significant antioxidant activity was observed for the cloves essential oil and its emulsion.
- All of our findings suggest that the aqueous by-products obtained during the cloves essential oil production are good candidates for future applications as preservatives in the cosmetics, food and pharma industry.

Acknowledgements

This work was supported by the Bulgarian National Science Fund (contract KP-06-H37/14)