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Extraction of Mentha Piperita Essential Oil Using Surfactants and Gc–Ms and Ftir Analysis

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Abstract: This article describes an environmentally friendly ("green chemistry") method for extracting essential oil from Mentha piperita (peppermint) using surfactants (soapstock, Tween-80, SDS). The extraction efficiency and chemical composition of the separated components were compared with the traditional steam distillation method and analyzed using GC–MS and FTIR analysis. According to the results of the study, when soapstock was used as a surfactant, the yield of essential oil increased by 18% and the main components (menthol, menthone, isomenthone, menthyl acetate) were detected in a higher percentage.

Keywords: Mentha piperita, surfactant, soapstock, GC–MS, FTIR, green chemistry, extraction.

Literature review

In recent years, there has been a growing interest in environmentally friendly and waste-free technologies for the extraction of essential oils. The traditional hydrodistillation method is time-consuming and energy-intensive, and also leads to thermal decomposition of some components (Ali & Khan, 2020). Therefore, surfactant-assisted extraction is proposed as a new, effective and environmentally friendly alternative method (Salehi et al., 2018). Soapstock is a waste product of oil production plants and is a cheap surfactant containing sodium salts, fatty acids and glycerin (Avezov & Homitova, 2023). Tween 80 and SDS are widely used as emulsifiers and provide high yields in the extraction of vegetable oils (Smith & Brown, 2021). GC–MS analysis allows for the qualitative and quantitative determination of essential oil components (Liu et al., 2022), and FTIR is important for determining their functional groups. Crystal phases in essential oils are also studied using X-ray structural analysis (X-ray diffraction), and electronic transitions are studied using UV–Vis.

Literature analysis shows that the development of a waste-free, "green chemistry"-based essential oil separation technology using soapstock as a surfactant is a scientifically and practically relevant issue.

The purpose of the study was to determine the optimal conditions for the separation of Mentha piperita essential oil using surfactants, to improve the soapstock-based extraction method, and to determine the chemical composition of the obtained essential oil based on GC–MS and FTIR analysis results.

Materials and methods. The leaves of Mentha piperita grown in the Bukhara region were used as the object of the study. The sample was dried in the shade at 25 ± 2 °C.

Extraction methods

1. Conventional steam distillation: carried out in a Clevenger apparatus for 3 hours.
2. Surfactant extraction: carried out with 1% soapstock, Tween-80 or SDS solution in a ratio of 1:5, at 60 °C for 2 hours.

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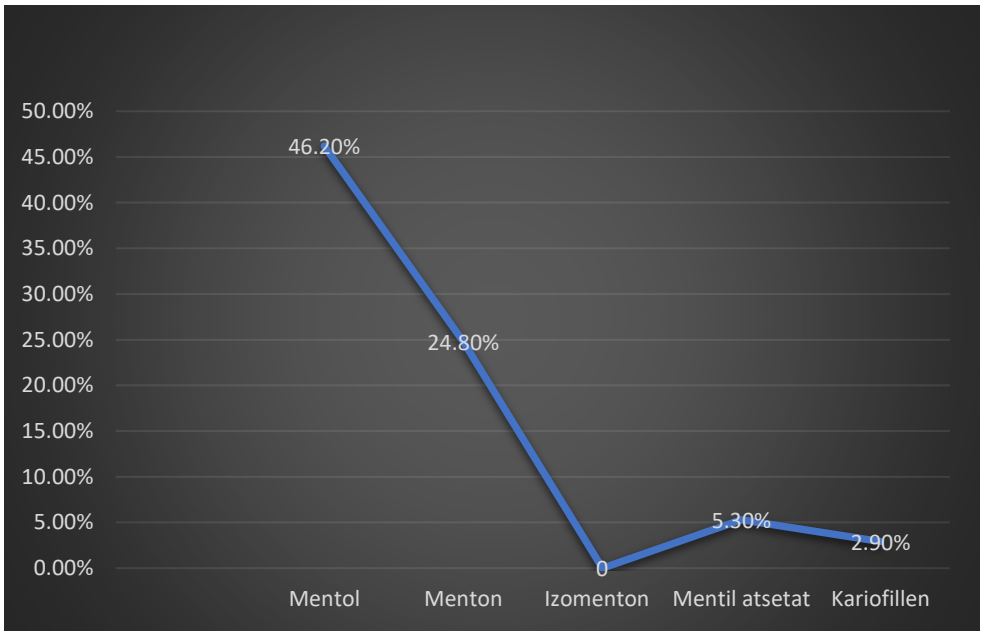
The separated essential oils were dried over Na_2SO_4 and prepared for GC–MS analysis.

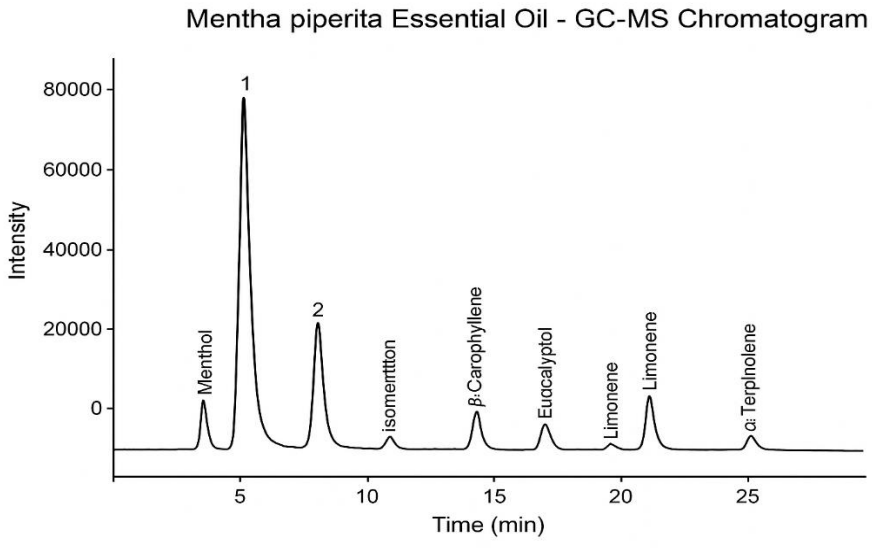
GC–MS analysis was performed using an Agilent 7890A GC, 5975C MS detector.

- Column: HP-5MS (30 m × 0.25 mm, 0.25 µm)
- Injection temperature: 250 °C
- Initial temperature: 60 °C (2 min), ramped to 220 °C at 5 °C/min
- Ionization energy: 70 eV
- Library: NIST and Wiley

The main components according to GC–MS analysis were:

- Menthol — 46.2%
- Menthone — 24.8%
- Isomethone — 6.7%
- Menthyl acetate — 5.3%
- Caryophyllene — 2.9%





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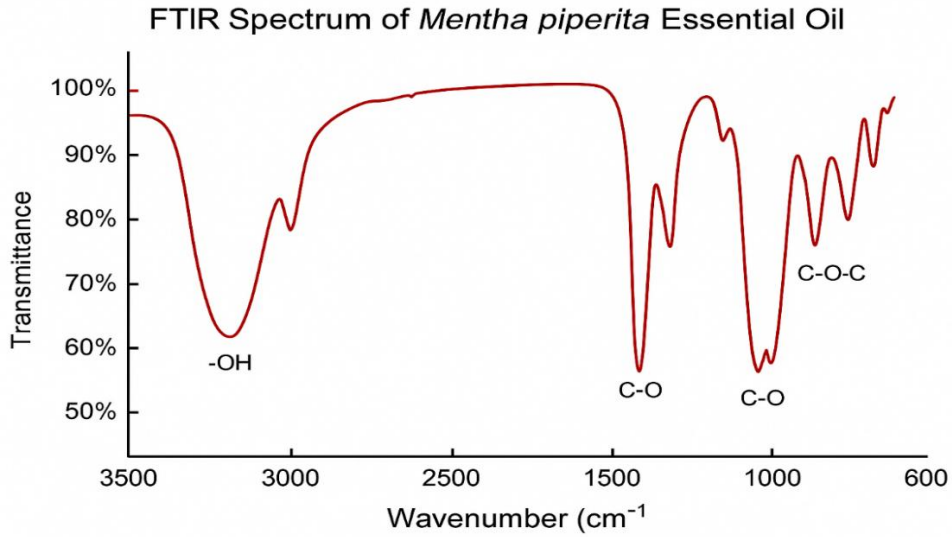
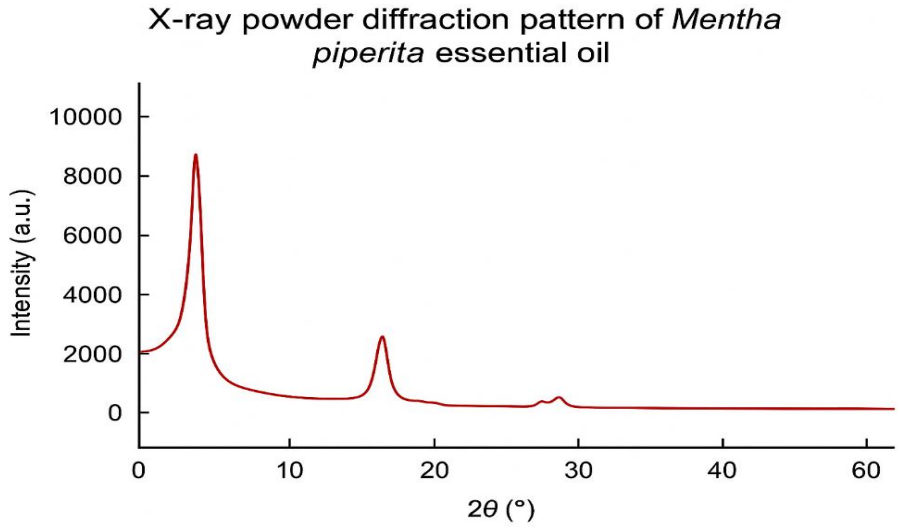
- FTIR analysis was performed on a PerkinElmer Spectrum Two FTIR spectrometer in the range of 400–4000 cm^{-1}. KBr tablets were prepared.
- UV–Vis and RSA. UV-1800 spectrophotometer in the range of 200–400 nm, RSA (XRD) analysis was performed on a Bruker D8 Advance instrument.
- Results and discussion. The yield of essential oil when extracted using soapstock was 1.8 ml/100 g, which was 18% higher than that obtained by conventional distillation.

Peaks corresponding to the –OH, C=O, and C–O–C functional groups were detected through the FTIR spectra. This confirms the presence of alcohol, ketone, and ether mixtures in the essential oil.



RSA results showed that the essential oil was partially crystalline.



Conclusion

Extraction using soapstock is an environmentally friendly and economically viable method for obtaining essential oils. GC–MS analysis of Mentha piperita essential oil revealed menthol as the main component. FTIR and RSA analyses provided a complete picture of the structural groups and phase states. This method is based on the principles of "green chemistry" and allows the implementation of waste-free technology.

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