



From Waste to Wealth: Valorizing Pomegranate Seeds into Bioactive Oil by Microwave and Soxhlet Extraction



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INTRODUCTION

The growing global interest in utilizing plant-derived by-products as sources of functional ingredients stems from their environmental, economic, and health benefits, stimulating the development of innovative extraction methods. Pomegranate (*Punica granatum* L.), valued for its high nutritional value and richness in bioactive compounds, generates significant amounts of processing waste, mainly in the form of peels and seeds, which may pose environmental challenges [1]. Approximately 50% of the pomegranate fruit is discarded during juice production, underscoring the importance of effective valorization strategies. One promising approach is the extraction of pomegranate seed oil (PSO), which enables the conversion of waste into a high-value raw material [2].

MATERIAL AND METHODS



The aim of this study was to compare the physicochemical properties of PSO obtained using microwave-assisted extraction and Soxhlet extraction.

Material: *Hicaz* variety pomegranate seeds, a by-product of juice pressing.



SOXHLET EXTRACTION

Oil was extracted using a Soxhlet apparatus.

Ground seeds (20.000 ± 0.001 g, milled at 25,000 rpm in an IKA Tube Mill) were wrapped in filter paper, placed in a thimble and extracted with 200 mL hexane for 6 h.

MICROWAVE ASSISTED EXTRACTION

The extraction parameters were selected based on the study by Çavdar et al. 2017 [3]. The extraction conditions were as follows: *P/W* 220 W, time 5 minutes, solvent/sample ratio: 10:1 and *d*=0.125 – 0.450 mm.



Extracts were dried with $MgSO_4$, filtered, and solvents removed using a Rotavapor® R-300. Residual n-hexane was eliminated under nitrogen.

PHYSICOCHEMICAL ANALYSES

The degree of hydrolysis of the investigated oils and the content of primary oxidation products of the oils were determined according to the AOCS methods [4,5]. The fat fraction was analyzed for fatty acid composition by gas chromatography (GC) and oxidative stability using pressure differential scanning calorimetry (PDSC).

SUMMARIZED RESULTS AND CONCLUSIONS

- Microwave-assisted extraction provided a higher yield ($12.05 \pm 0.27\%$) than Soxhlet ($11.49 \pm 0.22\%$) in a shorter process time, without deterioration of quality.
- Freshness and primary-oxidation indices were similar and within Codex Alimentarius requirements, indicating no advanced hydrolysis and limited primary oxidation.
- The fatty-acid profiles of both oils were practically identical and typical of PSO: over 85% polyunsaturated fatty acids, dominated by ~70% punicic acid (an isomer of conjugated linolenic acid), with low SFA and MUFA levels.
- Despite acceptable quality parameters, both oils showed short oxidation induction times, reflecting their very high PUFA content and resulting in low oxidative stability.
- Consequently, MAE should be considered a more efficient method for recovering bioactive PSO from waste, with quality comparable to Soxhlet, but requiring strict storage control and potentially antioxidant supplementation due to limited oxidative shelf-life.

REFERENCES

- [1] Talekar, S.; Patti, A.F.; Singh, R.; Vijayraghavan, R.; Arora, A. From Waste to Wealth: High Recovery of Nutraceuticals from Pomegranate Seed Waste Using a Green Extraction Process. *Industrial Crops and Products* 2018, *112*, 790–802, doi:10.1016/j.indcrop.2017.12.023
- [2] .Ko, K.; Dadmohammadi, Y.; Abbaspourrad, A. Nutritional and Bioactive Components of Pomegranate Waste Used in Food and Cosmetic Applications: A Review. *Foods* 2021, *10*, 657, doi:10.3390/foods10030657.
- [3] Çavdar, H.K.; Yanık, D.K.; Gök, U.; Göğüş, F. Optimisation of Microwave-Assisted Extraction of Pomegranate (*Punica Granatum* L.) Seed Oil and Evaluation of Its Physicochemical and Bioactive Properties. *Food Technol Biotechnol* 2017, *55*, 86–94, doi:10.17113/ftb.55.01.17.4638.
- [4] AOCS Official Method Te 1a-64; Acid Value Official Methods and Recommended Practices of the AOCS. AOCS: Urbana, IL, USA, 2009.
- [5].AOCS Official Method Cd 8b-90; Peroxide Value Acetic Acid-Isooctane Method Official methods and Recommended Practices of the AOCS. AOCS: Urbana, IL, USA, 2009

RESULTS

Table 1. Pomegranate seed oil extraction yield and quality parameters.

	Yield [%]	AV [mg KOH/g]	PV [meq O ₂ /kg]	p-Av	TOTOX (2PV + p-AnV)
PSO_MAE	12.05±0.27	3.48±0.12	3.16±0.18	14.11±0.20	20.43±0.19
PSO_SE	11.49±0.22	3.63±0.14	3.18±0.13	14.27±0.22	20.63±0.21

Where: **PSO_MAE** pomegranate seed oil extracted by microwave assisted extraction ; **PSO_SE**: pomegranate seed oil extracted by the Soxhlet method.

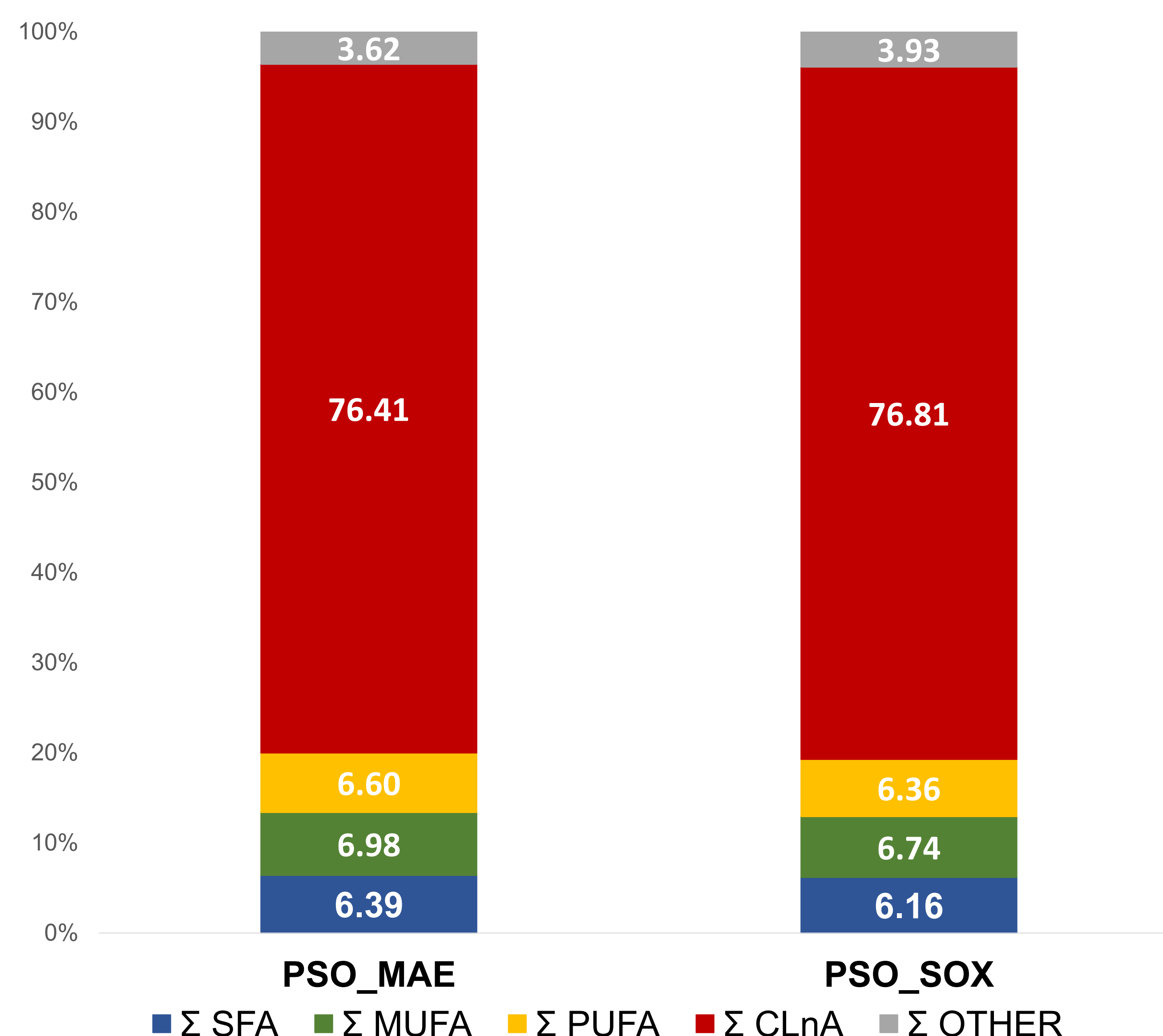


Figure 1. Fatty acid profile [%] of pomegranate seed oils.

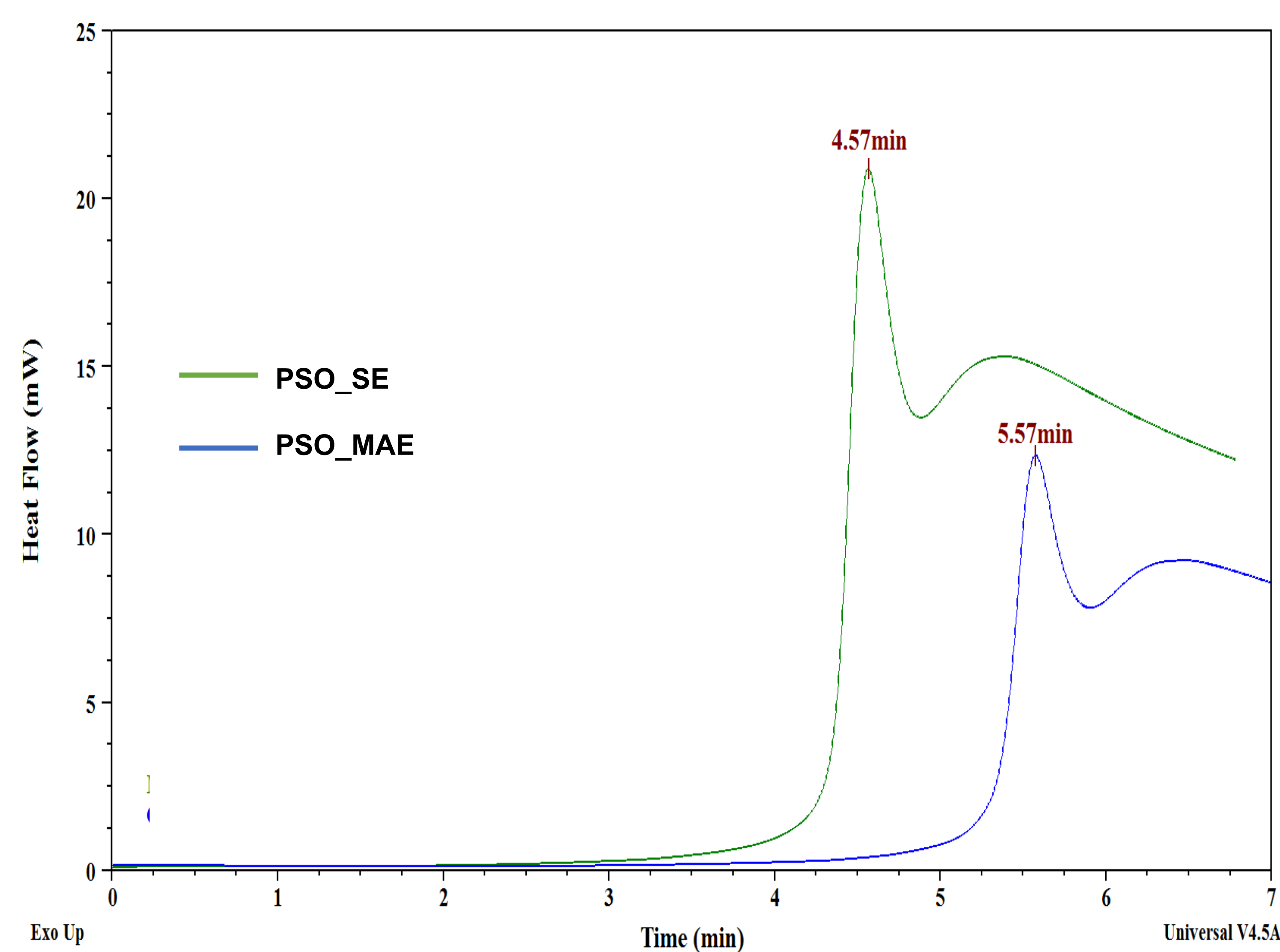


Figure 2. Oxidation induction time (OIT) curves of obtained oils.

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