Supporting Information

Highly effective extraction method for tea essential oil by microwave-assisted hydrodistillation for antioxidant application

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Calculation of carbon emissions

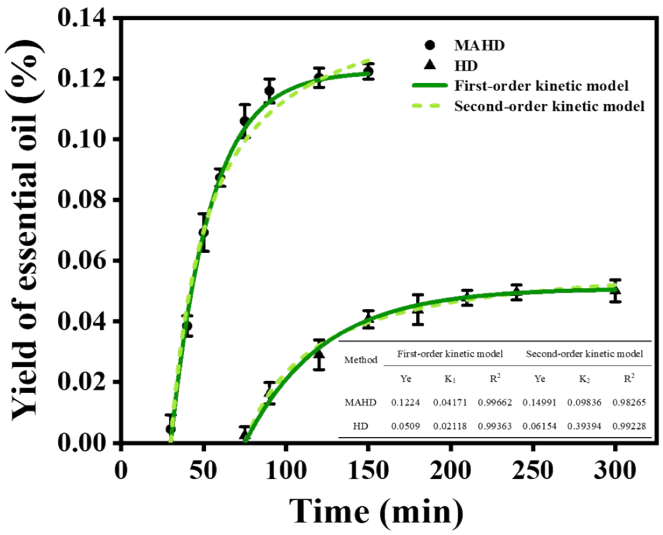
The CO_2 emissions associated with electricity consumption during the extraction process were calculated using the emission factor method based on the following formula

$$E_{CO_2} = EC \times EF$$

Among them E_{CO_2} is the CO_2 emission (g CO_2), EC is the electricity consumption (kWh), EF is the CO_2 emission factor.

According to the "Announcement on the Release of 2023 Carbon Dioxide Emission Factors for Electricity" jointly issued by the Ministry of Ecology and Environment of China and the National Bureau of Statistics (Announcement No. 47, 2025), the national fossil energy power CO_2 emission factor for 2023 is 0.8273 kg CO_2/kWh (827.3 g CO_2/kWh). According to the default value for grid-connected renewable power generation in the Clean Development Mechanism (CDM) method ACM0002, the figure of 800 g of CO_2 per kWh was adopted.

Supplementary figures



Method	First-order kinetic model			Second-order kinetic model		
	Ye	K_1	R^2	Ye	K_2	R^2
MAHD	0.1224	0.04171	0.99662	0.14991	0.09836	0.98265
HD	0.0509	0.02118	0.99363	0.06154	0.39394	0.99228

Figure S1 Kinetic profiles of essential oil extraction from Maojian tea leaves using different method.

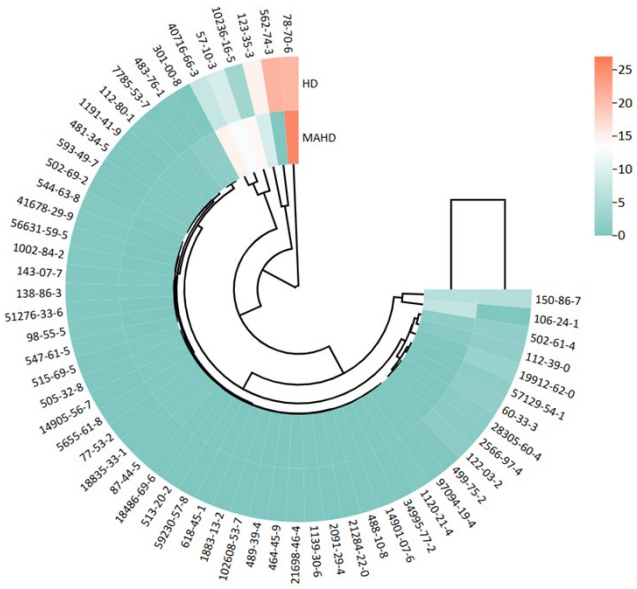


Figure S2 Heatmap of the cyclic clustering of the composition of MJEO.

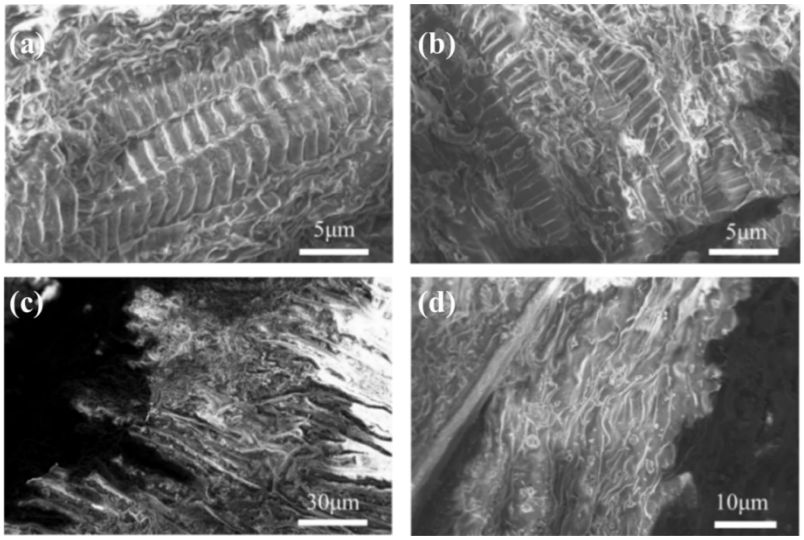


Figure S3 SEM images (a) and (b) of the Maojian tea leaves before extraction using MAHD, and (c) and (d) of the residue of Maojian tea leaves after extraction.

Supplementary table

Table S1 Factors and levels in the experiment

Level	Experimental Factor	
	Solid-to-liquid Ratio/ g·mL^{-1}	Microwave Power/ W
-1	1:3	252
0	1:4	406
1	1:5	567

Table S2 Experiment design and result of response surface method analysis.

Run	A	B	Yield of essential oil / %
1	406	1:4	0.1252
2	252	1:5	0.0560
3	406	1:4	0.1201
4	252	1:4	0.0805
5	406	1:5	0.0793
6	406	1:3	0.0607
7	406	1:4	0.1225
8	406	1:4	0.1209
9	567	1:4	0.1073
10	406	1:4	0.1178
11	567	1:5	0.0847
12	567	1:3	0.0658
13	252	1:3	0.0565

Table S3 Variance analysis for the established regression model.

Source	Sum of Squares	Degree of freedom	Mean square	F-value	p-value	Significance
Model	0.0091	5	0.0018	191.54	＜0.0001	***
A	0.0007	1	0.0007	73.98	＜0.0001	***
B	0.0003	1	0.0003	26.91	0.0013	**
AB	0.0001	1	0.0001	9.85	0.0164	*
A^2	0.0028	1	0.0028	291.14	＜0.0001	***
B^2	0.0048	1	0.0048	508.39	＜0.0001	***
Residual	0.0001	7	9.460×10^{-6}			
Lack of fit	0.0000	3	0.0000	1.56	0.3301	
Pure error	0.0000	4	7.625×10^{-6}			
Cor Total	0.0091	12		-		
R^2					0.9927	
R^2_{Adj}					0.9876	
R^2_{Pred}					0.9650	

* p < 0.05, significant; * * p < 0.01, highly significant; * ** p < 0.001, extremely significant.