Evaluation of the Biotechnological Potential of the Endangered Species *Eryngium maritimum* L. for Producing High-Quality Botanicals for Cosmetic Applications

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Background

Eryngium maritimum L. is a rare and endangered halophyte exceptionally rich in specialized metabolites: phenolic acids, flavonoids, and triterpenoid saponins [1]. These compounds exhibit antioxidant, anti-inflammatory, and antibacterial properties [2]. Current industrial approaches predominantly rely on undifferentiated callus cultures of *E. maritimum* which produce simplified phytochemical profiles [3]. There is a need for sustainable systems delivering phytochemically complex botanicals for cosmetic use.

Aim of the study

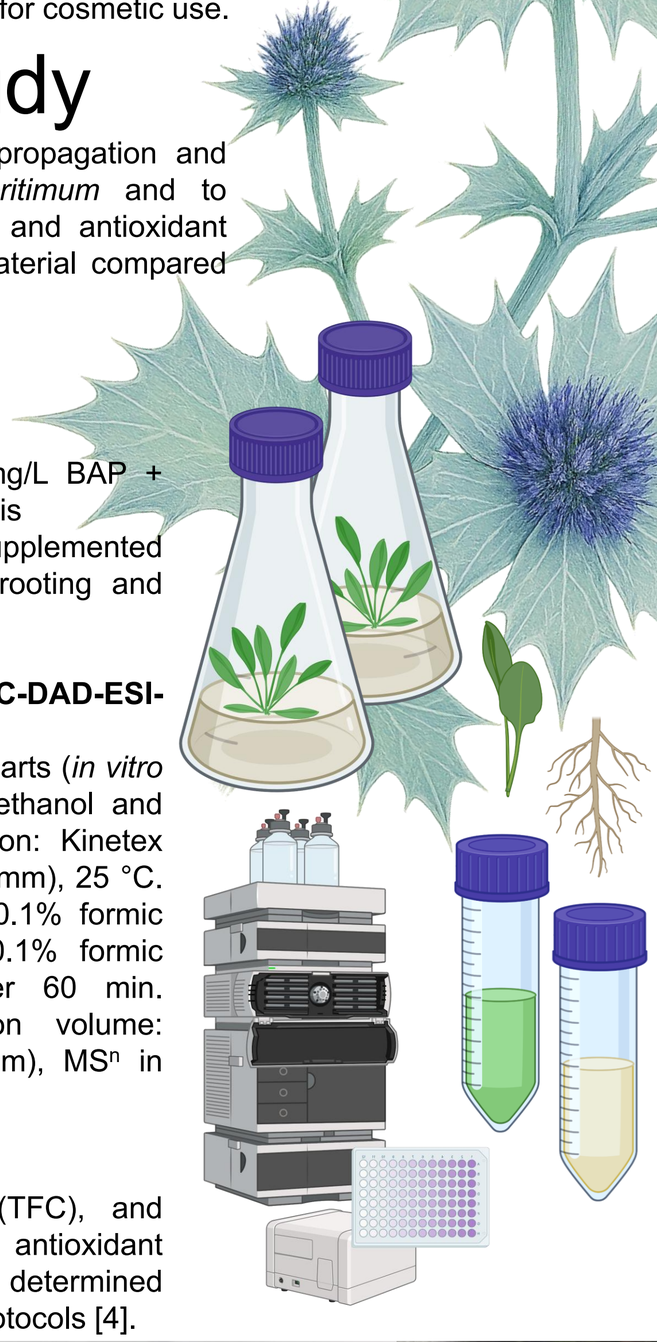
To establish an efficient micropropagation and organ culture system for *E. maritimum* and to evaluate the phytochemical quality and antioxidant potential of *in vitro*-derived plant material compared with *ex vitro* plants.

Methods

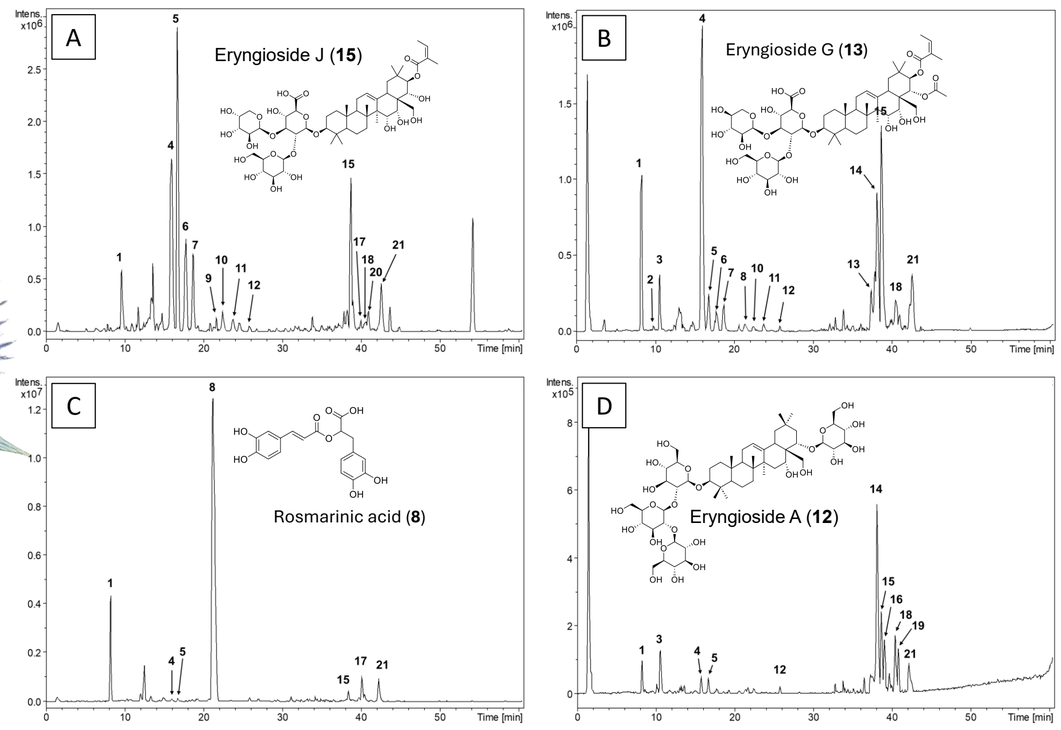
Micropropagation protocol:
MS medium + 2% glucose, 2.0 mg/L BAP + 0.25 mg/L IAA → shoot organogenesis
MS/3 (1/3 strenght MS) medium supplemented with 5 g/L activated charcoal → rooting and plantlet development

Phytochemical profiling (UHPLC-DAD-ESI-MS³):
Extracts of aerial and underground parts (*in vitro* and *ex vitro*) were prepared in methanol and filtered (0.45 µm PVDF). Separation: Kinetex XB-C18 column (1.7 µm, 150 × 2.1 mm), 25 °C. Gradient elution: solvent A (water/0.1% formic acid) and solvent B (acetonitrile/0.1% formic acid), from 5% to 99% B over 60 min. Flow rate: 0.3 mL/min; injection volume: 5 µL. Detection: DAD (200–450 nm), MS^n in negative ion mode (m/z 70–2200).

Spectrophotometric assays:
Total phenolic (TPC), flavonoid (TFC), and saponin content (TSC), as well as antioxidant activity (DPPH, FRAP), were determined according to previously described protocols [4].



Results



No	R_t	UV_{max} [nm]	Compound	$[M-H]^-$	MS^2
1	8.3	300sh, 325	3-O-caffeoylquinic acid*	353	191; 179
2	9.6	275, 325	Quinic acid derivative	551	191
3	10.6	300sh, 325	Feruloylquinic acid	367	191
4	15.9	260, 340	Kaempferol dirhamnoside	577	431; 285
5	16.7	265, 345	Quercetin di-O-acetylglucoside	547	301
6	17.8	265, 345	Kaempferol glucoside	447	285
7	18.6	265, 345	Isorhamnetin glucoside	547	315
8	21.4	290sh; 330	Rosmarinic acid*	359	
9	21.4	325	Quercetin derivative	679	301
10	22.4	265, 345	Kaempferol xylosylrhamnoside	563	285

No	R_t	UV_{max} [nm]	Compound	$[M-H]^-$	MS^2
11	23.8	350	Isorhamnetin derivative	565	315
12	25.8	-	Eryngioside A	1121	
13	37.4	-	Eringioside G	1057	
14	37.9	-	Eryngioside J	1099	
15	38.7	-	Eryngioside M	1099	
16	39.1	-	Unidentified saponin I	1101	
17	40.0	-	Eryngioside H	1041	
18	40.4	-	Unidentified saponin II	937	788
19	40.9	-	Unidentified saponin III	785	410
20	41.0	-	Eryngioside L	1083	
21	42.2	-	Unidentified saponin IV	879	729

**confirmed with standard*

Fig. 2. Representative UHPLC-DAD-ESI-MS^3 chromatograms of methanolic extracts of *E. maritimum:* (A) Shoots *ex vitro* (Sh-EX), (B) Shoots *in vitro* (Sh-IV), (C) Roots *ex vitro* (Ro-EX), (D) Roots *in vitro* (Ro-IV). Numbers on chromatograms correspond to metabolites listed in the table. Compounds were identified either by comparison with standards (*) or tentatively based on MS^n fragmentation patterns and literature data.

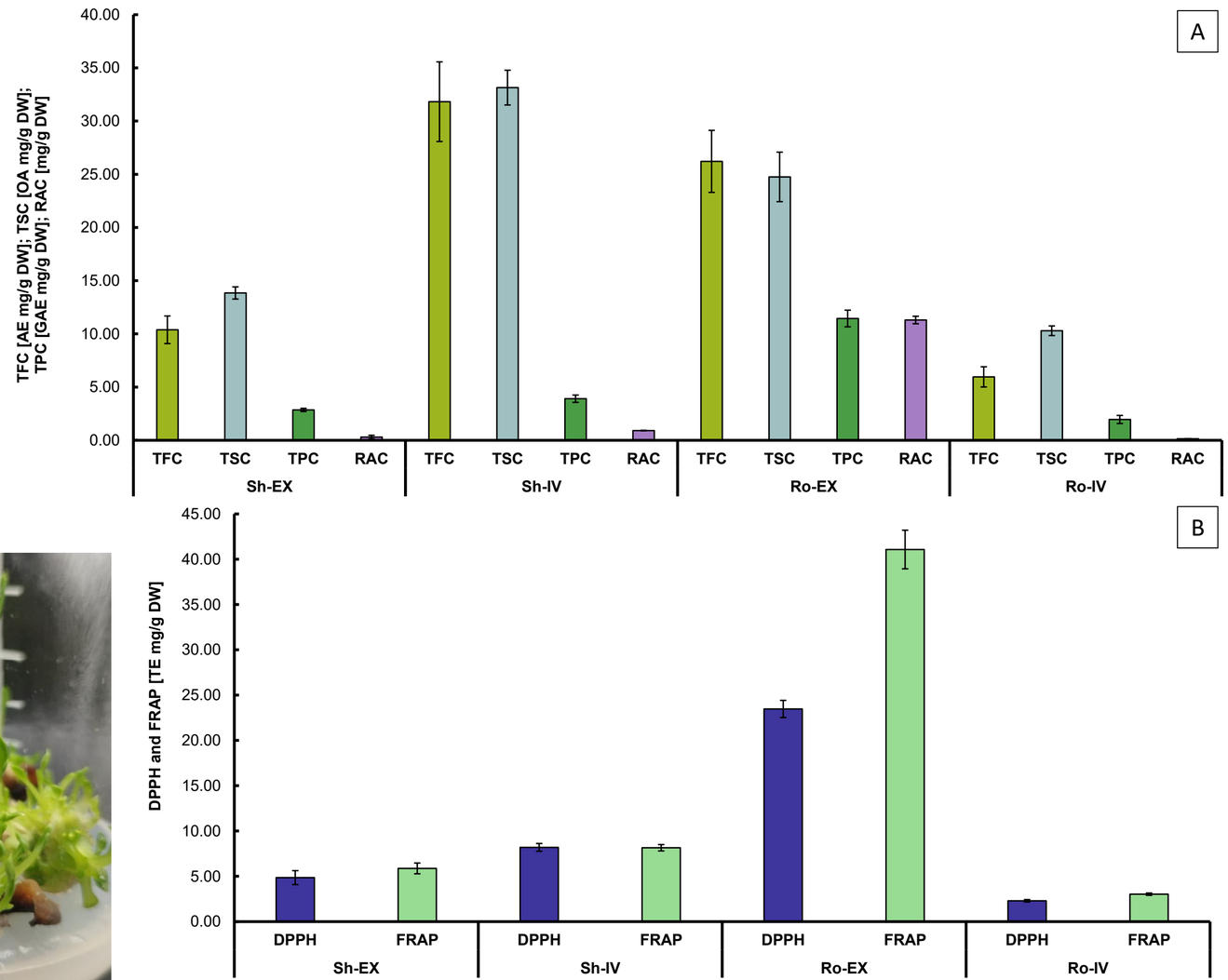


Fig. 3. (A) Total flavonoid content (TFC) [QE mg/g DW], total saponin content (TSC) [OA mg/g DW], total phenolic content (TPC) [GAE mg/g DW], rosmarinic acid content [mg/g DW] determined in methanolic extracts. (B) Antioxidant activity determined with DPPH· radical scavengening method and FRAP method [TE mg/g DW]. QE – quercetin equivalent; OA – oleanolic acid equivalent; GAE – gallic acid equivalent; TE – trolox equivalent.

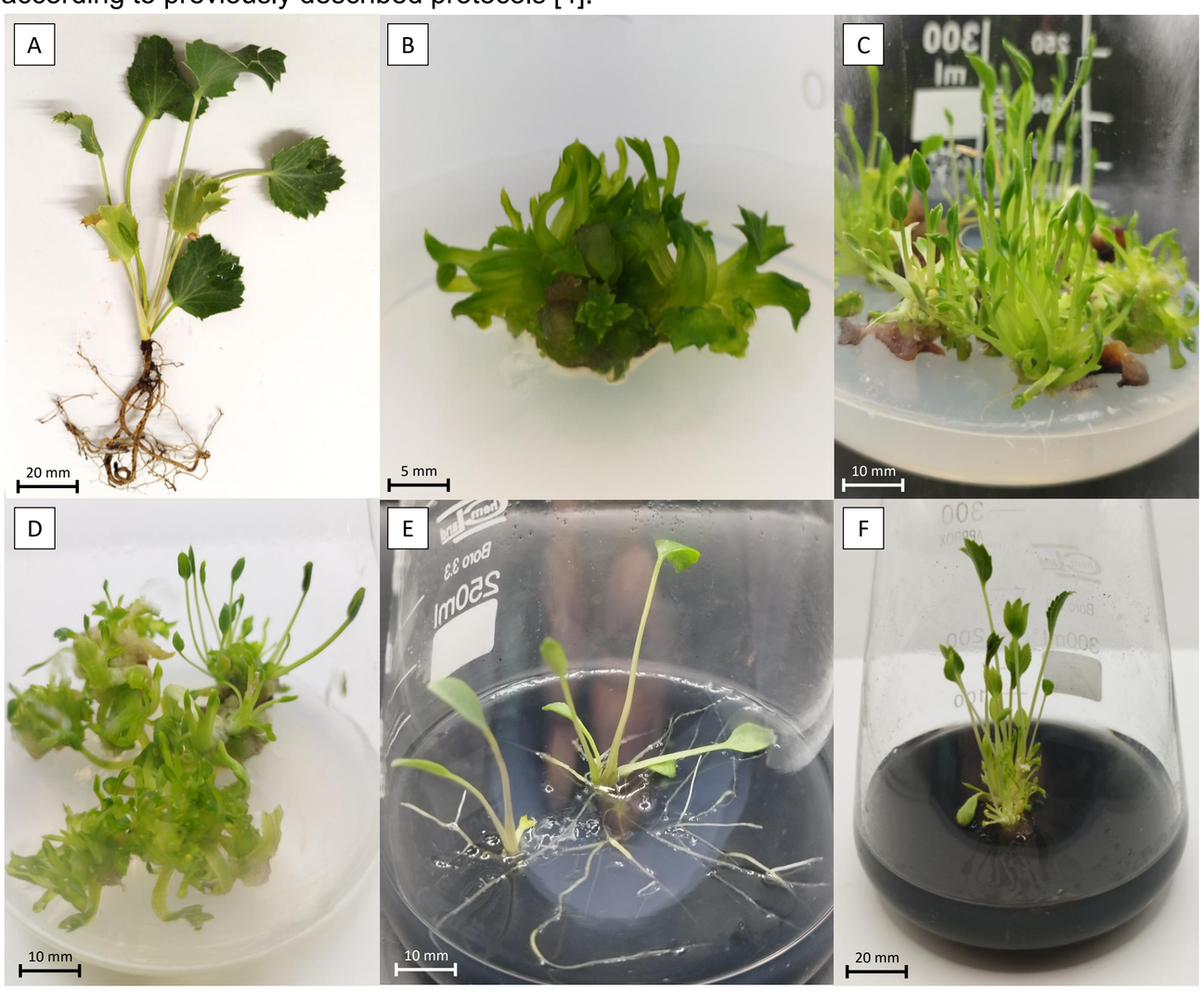


Fig. 1 Stages of *E. maritimum* micropropagation: (A) *ex vitro* plant, (B) callus with shoot induction, (C) shoot organogenesis, (D) shoot multiplication, (E) rooting, (F) developed plantlets.

Highlights

- Micropropagation of *E. maritimum* provides an efficient and sustainable system for biomass production.
- *In vitro*-derived organs accumulate key secondary metabolites (saponins, rosmarinic acid).
- This approach can serve as a valuable alternative source of high-quality botanicals from this endangered species.

References:
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