

Article

Pharmacological and cosmeceutical potential of seaweed beach-casts of Macaronesia

Rafael Zárate ^{1,*}, Eduardo Portillo ², Sílvia Teixidó ¹, Miguel A. A. Pinheiro de Carvalho ³, Nuno Nunes ³, Sónia Ferraz ³, Ana M. L. Seca ^{4,5}, Gonçalo P. Rosa ⁴, Maria Carmo Barreto ^{4,*}

¹ Canary Islands Cancer Research Institute Foundation (FICIC), Ave. La Trinidad 61, Torre A. Arévalo, 7th floor, 38204 La Laguna, Spain; teixido.silvia@gmail.com

² Instituto Tecnológico de Canarias, Playa de Pozo Izquierdo s/n, 35119 Santa Lucía, Spain; eportillo@itccanarias.org

³ ISOPlexis—Centre in Sustainable Agriculture and Food Technology and Faculty of Life Sciences, University of Madeira, Campus da Penteada, 9020-105 Funchal, Portugal; miguel.carvalho@staff.uma.pt (M.A.A.P.d.C.); nuno.nunes@staff.uma.pt (N.N.); sferraz81@staff.uma.pt (S.F.)

⁴ cE3c—Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group and Faculty of Sciences and Technology, University of Azores, 9500-321 Ponta Delgada, Portugal; ana.ml.seca@uac.pt (A.M.L.S.); goncalo.p.rosa@uac.pt (G.P.R.)

⁵ LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal

* Correspondence: rzarate@icic.es (R.Z.); maria.cr.barreto@uac.pt (M.C.B.); Tel.: +34-822102807 (R.Z.); +351-296650183 (M.C.B.)

Received: 20 July 2020; Accepted: 21 August 2020; Published: 23 August 2020

Table S1. Beach-cast composition, solvent extraction and sample codes of the samples studied.

Beach-casts	Beach-cast Composition	Extraction Solvent	Sample Code	Extraction Yield (g/100g dried algae)
1	95% <i>Lobophora variegata</i> and 5% various	Ethanol	1.E	14.13
		Methanol	1.M	16.89
2	57% <i>Halopithys incurva</i> , 32% <i>Dictyota</i> sp., 10.7% <i>Lobophora variegata</i> and 3% various	Ethanol	2.E	5.71
		Methanol	2.M	11.20
3	30.6% <i>Dictyota</i> sp., 30.5% <i>Jania</i> sp., 8.4% <i>Cymopolia barbata</i> , and 13.9% <i>Lobophora variegata</i>	Ethanol	3.E	2.52
		Methanol	3.M	5.20
4	50% <i>Asparagopsis taxiformis</i> , 41.6% <i>Dictyota</i> sp. and 8.4% <i>Stypocaulon scoparium</i>	Ethanol	4.E	2.88
		Methanol	4.M	4.55
5	56.45% <i>Asparagopsis taxiformis</i> , 21% <i>Lobophora variegata</i> , 14.5% <i>Dictyota</i> sp. and 8.05% <i>Stypocaulon scoparium</i>	Ethanol	5.E	2.87
		Methanol	5.M	3.73
6	45% <i>Asparagopsis taxiformis</i> , 25% <i>Lobophora variegata</i> , 21% <i>Dictyota</i> sp. and 9% <i>Stypocaulon scoparium</i>	Ethanol	6.E	3.33
		Methanol	6.M	6.85
7	39.1% <i>Dictyota</i> sp., 34.8% <i>Asparagopsis taxiformis</i> , 21.8% <i>Lobophora variegata</i> and 4.3% <i>Jania</i> sp.	Ethanol	7.E	1.90
		Methanol	7.M	3.66
8	36% <i>Dictyota</i> sp., 30% <i>Asparagopsis taxiformis</i> , 24% <i>Lobophora variegata</i> and 10% <i>Stypocaulon scoparium</i>	Ethanol	8.E	2.17
		Methanol	8.M	4.27
9	42% <i>Dictyota</i> sp., 28% <i>Asparagopsis taxiformis</i> , 22% <i>Lobophora variegata</i> and 8% <i>Stypocaulon scoparium</i>	Ethanol	9.E	1.83
		Methanol	9.M	9.13
10	33.8% <i>Asparagopsis taxiformis</i> , 28.6% <i>Lobophora variegata</i> , 22.6% <i>Dictyota</i> sp., 14.5% <i>Cymopolia barbata</i> and 0.5% <i>Laurencia</i> sp.	Ethanol	10.E	2.31
		Methanol	10.M	3.32
11	31.8% <i>Lobophora variegata</i> , 23.8% <i>Asparagopsis taxiformis</i> , 22.2% <i>Cymopolia barbata</i> and 22.2% <i>Dictyota</i> sp.	Ethanol	11.E	2.02
		Methanol	11.M	8.02
12	45% <i>Lobophora variegata</i> , 25% <i>Jania</i> sp., 20% <i>Dictyota</i> sp. and 10% <i>Cymopolia barbata</i>	Ethanol	12.E	4.03
		Methanol	12.M	5.47

13	68.71% <i>Stypocaulon scoparium</i> , 14.42% <i>Lobophora variegata</i> , 13.36% <i>Cymopolia barbata</i> and 3.51% <i>Liagora</i> sp.	Ethanol	13.E	2.57
		Methanol	13.M	2.66
14	100% <i>Lobophora variegata</i>	Ethanol	14.E	5.36
		Methanol	14.M	6.53
15	100% <i>Dictyota</i> sp.	Ethanol	15.E	4.71
		Methanol	15.M	6.01

Table S2. Fractionation of the most active extracts.

Extract of Origin	Fraction	Fractionation Solvent	Fractions Yield (mg/100 mg of dried extract)
1.E	1.E.1	Hexane	19.64
	1.E.2	Dichloromethane	17.09
	1.E.3	Chloroform	30.96
	1.E.4	Methanol/Water 1:1	19.58
1.M	1.M.1	Hexane	17.05
	1.M.2	Dichloromethane	16.54
	1.M.3	Chloroform	8.69
	1.M.4	Methanol/Water 1:1	42.68
2.M	2.M.1	Hexane	10.95
	2.M.2	Dichloromethane	3.19
	2.M.3	Chloroform	0.56
	2.M.4	Methanol/Water 1:1	79.10
5.M	5.M.1	Hexane	29.15
	5.M.2	Dichloromethane	7.52
	5.M.3	Chloroform	0.94
	5.M.4	Methanol/Water 1:1	57.89
12.E	12.E.1	Hexane	26.68
	12.E.2	Dichloromethane	4.08
	12.E.3	Chloroform	3.36
	12.E.4	Methanol/Water 1:1	27.70

Table S3. Antiradical scavenging activity of samples (IC₅₀) in µg/mL.

Sample code	ABTS	DPPH
1.E	6.21 ± 1.03	81.57 ± 2.05
1.M	13.09 ± 1.43	156.22 ± 3.06
2.E	7.20 ± 0.15	69.39 ± 1.23
2.M	24.66 ± 0.64	134.41 ± 1.54
3.E	>250	>250
3.M	>250	>250
4.E	>250	>250
4.M	>250	>250
5.E	>250	>250
5.M	>250	>250
6.E	>250	>250
6.M	>250	>250
7.E	>250	>250
7.M	>250	>250
8.E	>250	>250
8.M	>250	>250
9.E	>250	>250
9.M	>250	>250
10.E	>250	>250
10.M	>250	>250
11.E	176.04 ± 0.93	225.01 ± 1.73
11.M	242.78 ± 9.69	>250
12.E	203.13 ± 5.44	>250
12.M	149.82±9.12	>250
13.E	>250	>250
13.M	>250	>250
14.E	>250	>250
14.M	>250	>250
15.E	>250	>250
15.M	>250	>250
1.E.1	50.18 ± 0.62	67.35 ± 0.84
1.E.2	48.10 ± 0.43	213.34 ± 0.70
1.E.3	8.89 ± 0.26	>250
1.E.4	49.16 ± 0.47	>250
1.M.1	38.98 ± 0.69	>250
1.M.2	13.35 ± 0.77	193.08 ± 0.12
1.M.3	19.32 ± 0.61	229.06 ± 0.36
1.M.4	40.78 ± 0.16	>250
2.M.1	36.03 ± 0.22	54.83 ± 0.71
2.M.2	185.04 ± 0.81	71.70 ± 0.33
2.M.3	53.65 ± 0.51	50.21 ± 0.81
2.M.4	9.57 ± 0.40	>250
5.M.1	n.d	n.d
5.M.2	n.d	n.d
5.M.3	n.d	n.d
5.M.4	n.d	n.d
12.E.1	n.d	n.d
12.E.2	n.d	n.d
12.E.3	n.d	n.d
12.E.4	n.d	n.d
Trolox	2.68 ± 0.08	7.25 ± 0.09

n.d.—non determined

Table S4. Antiaging activity of samples (IC₅₀) in µg/mL.

Sample code	Tyrosinase	Elastase	Collagenase
1.E	59.12 ± 6.96	>250	193.22 ± 14.97
1.M	66.00 ± 10.30	>250	195.56 ± 6.06
2.E	200.09 ± 12.32	>250	>250
2.M	>250	>250	>250
3.E	>250	>250	>250
3.M	>250	>250	>250
4.E	>250	222.32±1.98	>250
4.M	>250	>250	>250
5.E	>250	223.44±0.79	41.04 ± 2.58
5.M	>250	>250	59.34 ± 2.99
6.E	213.86 ± 5.18	>250	>250
6.M	>250	>250	>250
7.E	154.13±13.71	>250	>250
7.M	>250	>250	>250
8.E	57.87±3.19	>250	>250
8.M	173.07±4.26	215.95±8.81	248.76±2.95
9.E	35.73 ± 0.86	>250	>250
9.M	50.11 ± 0.24	>250	>250
10.E	239.31 ± 5.38	>250	>250
10.M	>250	249.58 ± 0.72	>250
11.E	15.18 ± 0.44	226.90 ± 0.36	163.06 ± 1.26
11.M	32.85 ± 0.73	>250	163.53 ± 1.41
12.E	32.80 ± 0.69	209.56 ± 12.89	>250
12.M	67.33 ± 0.89	>250	242.16 ± 8.77
13.E	>250	>250	>250
13.M	>250	>250	>250
14.E	>250	>250	>250
14.M	>250	>250	>250
15.E	>250	>250	>250
15.M	>250	>250	>250
1.E.1	59.05±0.01	n.d	>250
1.E.2	19.12±0.01	n.d	>250
1.E.3	19.33±0.85	n.d	>250
1.E.4	24.29 ± 0.15	n.d	>250
1.M.1	70.14 ± 0.54	n.d	>250
1.M.2	54.65 ± 0.84	n.d	>250
1.M.3	95.21 ± 0.84	n.d	>250
1.M.4	49.87 ± 0.74	n.d	>250
2.M.1	n.d	n.d	n.d
2.M.2	n.d	n.d	n.d
2.M.3	n.d	n.d	n.d
2.M.4	n.d	n.d	n.d
5.M.1	n.d	n.d	>250
5.M.2	n.d	n.d	>250
5.M.3	n.d	n.d	>250
5.M.4	n.d	n.d	>250
12.E.1	9.01 ± 0.01	n.d	>250
12.E.2	46.64 ± 0.87	n.d	>250
12.E.3	28.70 ± 0.14	n.d	207.22 ± 0.81
12.E.4	76.87 ± 0.37	n.d	40.11 ± 0.88
Kojic Acid	1.82 ± 0.13	n.a	n.a
MAAPVCK	n.a	0.13 ± 0.002	n.a
EDTA	n.a	n.a	59.26 ± 3.01

n.d.—non determined; n.a. —not applicable



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).