

Supplementary Material

Tables













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Table S1. Color changes[#] and color simulation throughout storage days for *P. umbilicalis* and *U. lactuca* preserved by different treatments.

The results are expressed as the CIELAB coordinates for L^* , a^* , b^* , and the calculated color deviation (ΔE).

CIELAB Coordinates	Days	<i>Porphyra umbilicalis</i> (PU)			<i>Ulva lactuca</i> (UL)		
		CTRL	MAP	VAC	CTRL	MAP	VAC
L^*	Day 0	32.18 ^{a, A} [30.60, 35.54]	32.18 ^{a, A} [30.60, 35.54]	32.18 ^{a, A} [30.60, 35.54]	73.59 ^{a, A} [71.99, 76.84]	73.59 ^{a, A} [71.99, 76.84]	73.59 ^{ab, A} [71.99, 76.84]
	Day 3	36.84 ^{a, A} [34.73, 37.24]	35.24 ^{ab, A} [34.00, 37.1]	34.47 ^{a, A} [33.82, 35.65]	76.58 ^{ab, A} [76.38, 78.41]	77.56 ^{ab, A} [75.75, 77.97]	71.41 ^{b, B} [70.46, 74.79]
	Day 6	33.79 ^{a, A} [33.07, 35.53]	37.38 ^{b, A} [34.8, 38.89]	36.38 ^{ab, A} [33.38, 39.16]	78.80 ^{bc, A} [77.11, 80.39]	77.35 ^{ab, A} [75.68, 78.8]	78.08 ^{ac, A} [76.63, 80.15]
	Day 9	36.55 ^{a, A} [34.93, 38.77]	34.38 ^{ab, A} [30.42, 35.95]	34.35 ^{a, A} [31.32, 39.21]	76.27 ^{ab, AB} [75.87, 77.82]	78.37 ^{b, A} [77.62, 79.23]	74.02 ^{b, B} [69.85, 76.86]
	Day 12	36.73 ^{a, A} [35.29, 39.00]	37.42 ^{b, A} [35.45, 40.57]	41.00 ^{b, A} [39.41, 45.03]	77.02 ^{ab, A} [73.18, 78.52]	77.71 ^{ab, A} [75.82, 78.46]	78.48 ^{c, A} [77.16, 79.6]
	Day 15	36.55 ^{a, A} [36.00, 37.28]	36.51 ^{ab, A} [34.38, 39.72]	42.61 ^{b, A} [39.55, 43.19]	81.41 ^{c, A} [79.88, 81.86]	77.03 ^{ab, B} [73.85, 77.74]	79.32 ^{c, A} [78.25, 80.68]
a^*	Day 0	6.72 ^{a, A} [6.19, 8.32]	6.72 ^{a, A} [6.19, 8.32]	6.72 ^{ac, A} [6.19, 8.32]	-14.73 ^{a, A} [-16.50, -13.82]	-14.73 ^{a, A} [-16.50, -13.82]	-14.73 ^{a, A} [-16.50, -13.82]
	Day 3	5.18 ^{ab, A} [4.20, 5.52]	3.73 ^{b, A} [2.84, 4.94]	4.59 ^{b, A} [3.97, 5.69]	-13.87 ^{ab, A} [-14.95, -13.16]	-12.70 ^{b, A} [-13.37, -11.93]	-14.72 ^{a, A} [-16.02, -13.53]
	Day 6	3.63 ^{b, A} [3.09, 4.28]	4.68 ^{bc, A} [2.65, 5.28]	4.06 ^{b, A} [3.34, 4.93]	-14.04 ^{ab, A} [-14.76, -13.57]	-11.49 ^{bc, B} [-12.14, -10.93]	-10.36 ^{bc, B} [-11.20, -10.18]
	Day 9	5.17 ^{ab, A} [4.54, 6.34]	6.35 ^{ac, A} [5.31, 7.68]	5.41 ^{ab, A} [4.30, 6.69]	-13.02 ^{ab, A} [-14.03, -12.37]	-10.08 ^{c, B} [-10.79, -9.44]	-10.73 ^{b, B} [-12.04, -10.46]
	Day 12	3.58 ^{b, A} [3.22, 4.39]	9.19 ^{a, B} [7.67, 10.70]	8.36 ^{c, B} [7.55, 13.20]	-12.93 ^{b, A} [-13.72, -12.67]	-10.74 ^{c, B} [-11.93, -9.84]	-10.64 ^{bc, B} [-11.31, -9.97]
	Day 15	4.18 ^{b, A} [3.66, 5.28]	7.27 ^{a, B} [5.72, 9.87]	13.25 ^{c, B} [10.17, 15.35]	-10.58 ^{c, A} [-11.31, -9.50]	-9.17 ^{c, A} [-10.88, -8.78]	-8.43 ^{c, A} [-9.16, -7.96]
b^*	Day 0	27.74 ^{a, A} [26.85, 28.41]	27.74 ^{a, A} [26.85, 28.41]	27.74 ^{a, A} [26.85, 28.41]	44.61 ^{a, A} [43.59, 47.05]	44.61 ^{a, A} [43.59, 47.05]	44.61 ^{ab, A} [43.59, 47.05]
	Day 3	24.07 ^{a, A} [22.81, 27.04]	23.55 ^{abc, A} [22.22, 25.99]	24.01 ^{ab, A} [22.84, 26.63]	45.76 ^{a, A} [39.3, 47.83]	48.97 ^{a, AB} [40.98, 50.71]	55.44 ^{b, B} [51.08, 56.86]
	Day 6	24.67 ^{a, A} [23.60, 26.08]	26.56 ^{ab, A} [24.93, 27.30]	25.31 ^{ab, A} [24.10, 26.34]	35.42 ^{ab, A} [32.46, 43.8]	42.32 ^{ab, A} [40.53, 47.29]	37.44 ^{ac, A} [32.94, 47.00]
	Day 9	26.97 ^{a, A} [24.64, 28.4]	24.66 ^{bc, AB} [23.48, 25.26]	22.59 ^{bc, B} [21.93, 23.18]	41.15 ^{a, A} [32.36, 45.64]	35.71 ^{b, A} [32.34, 41.59]	49.49 ^{b, B} [47.40, 53.18]
	Day 12	26.49 ^{a, A} [25.80, 28.26]	22.33 ^{c, B} [20.49, 23.88]	19.62 ^{bc, B} [2.67, 24.84]	41.80 ^{a, A} [38.60, 44.68]	35.90 ^{ab, A} [34.96, 49.28]	37.06 ^{ac, A} [35.10, 40.44]
	Day 15	27.13 ^{a, A} [25.33, 29.44]	19.31 ^{bc, B} [11.19, 25.17]	1.68 ^{c, B} [0.86, 8.39]	27.38 ^{b, A} [25.94, 28.57]	46.76 ^{a, B} [41.66, 49.3]	34.83 ^{c, A} [32.75, 36.76]
ΔE	Day 0	–	–	–	–	–	–
	Day 3	6.19 ^{a, A} [5.12, 8.19]	7.21 ^{a, A} [5.06, 8.48]	5.24 ^{a, A} [3.45, 6.86]	4.65 ^{a, A} [3.62, 7.36]	6.64 ^{a, A} [6.05, 7.27]	10.62 ^{a, A} [8.69, 12.6]
	Day 6	5.35 ^{a, A} [3.80, 6.07]	6.49 ^{a, A} [4.87, 8.25]	5.79 ^{ab, A} [4.58, 8.13]	10.89 ^{a, A} [4.92, 14.56]	6.59 ^{a, A} [5.45, 7.72]	11.4 ^{a, A} [7.62, 14.41]
	Day 9	4.97 ^{a, A} [2.87, 7.26]	4.69 ^{a, A} [4.03, 6.34]	6.85 ^{ab, A} [5.80, 8.85]	6.12 ^{a, A} [4.20, 13.58]	11.34 ^{a, A} [7.73, 15.38]	7.80 ^{a, A} [6.05, 10.08]
	Day 12	5.16 ^{a, A} [4.92, 7.13]	7.56 ^{a, A} [5.76, 11.48]	10.86 ^{bc, A} [6.90, 29.03]	5.91 ^{a, A} [4.14, 9.86]	11.40 ^{a, A} [7.98, 12.86]	10.33 ^{a, A} [8.11, 12.14]
	Day 15	5.48 ^{a, A} [4.92, 6.08]	9.26 ^{a, A} [4.00, 17.69]	28.77 ^{c, B} [20.66, 29.95]	19.66 ^{b, A} [18.05, 21.53]	8.14 ^{a, B} [7.78, 9.35]	13.11 ^{a, AB} [12.06, 15.51]
Color Simulation	Day 0						
	Day 3						
	Day 6						
	Day 9						
	Day 12						
	Day 15						

[#] **Notes:** Medians and interquartile range (IQR) [Q1, Q3] from duodecuple determinations on each experiment. Medians in the same column followed by a different lowercase letter are significantly different ($P < 0.05$) throughout storage days. Medians in the same row followed by a different uppercase letter are significantly different ($P < 0.05$) among treatments.

Table S2. Microbial counts* for Coliforms, *E. coli*, Coagulase-positive Staphylococci, *Vibrio* spp., *Salmonella* spp., and *L. monocytogenes* at storage days 0 and 15 for *P. umbilicalis* and *U. lactuca* preserved by different treatments.

The results are expressed as the logarithm of colony-forming unit per gram of sample (log CFU.g⁻¹).

Microbiological Analysis	<i>Porphyra umbilicalis</i> (PU)				<i>Ulva lactuca</i> (UL)			
	Day 0 CTRL	Day 15 CTRL	Day 15 MAP	Day 15 VAC	Day 0 CTRL	Day 15 CTRL	Day 15 MAP	Day 15 VAC
Coliforms	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
<i>Escherichia coli</i>	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
Coagulase-positive Staphylococci [#]	2.7637	2.6505	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
<i>Vibrio</i> spp.	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
<i>Salmonella</i> spp.	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
<i>Listeria monocytogenes</i>	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D

* Notes: LOD = Limit of Detection; N/D = Not Detected; *Day 0* (n = 2 petri dishes x 2 dilutions x 4 repetitions = 16); *Day 15* (n = 2 petri dishes x 2 dilutions x 1 repetition = 4, for each treatment); LOD < 1 log CFU.g⁻¹ for coliforms and *Escherichia coli*, and LOD < 2 log CFU.g⁻¹ for Coagulase-positive Staphylococci and *Vibrio* spp.

[#] Observation: Black colonies without halo, non-characteristic of coagulase-positive Staphylococci.

Analysis of Variance of Aligned Rank Transformed Data

Table Type: ANOVA Table (Type III tests)

Model: No Repeated Measures (LM)

Response: art(Values)

Equation: Values ~ Days + Treatments + Days:Treatments

Table S3a. ANOVA results for the GC-TOF-MS analysis of *Porphyra umbilicalis*

	Variables	Df	Df.res	F value	Pr(>F)	Signif.
1	Days	5	2250	1.87202	0.096001	.
2	Treatments	2	2250	0.39675	0.672550	
3	Days:Treatments	10	2250	0.28115	0.985454	

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S3b. ANOVA results for the GC-TOF-MS analysis of *Ulva lactuca*

	Variables	Df	Df.res	F value	Pr(>F)	Signif.
1	Days	5	2646	18.9221	< 2.22e-16	***
2	Treatments	2	2646	14.4729	5.6058e-07	***
3	Days:Treatments	10	2646	7.3507	1.3834e-11	***

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S3c. Tukey HSD for the GC-TOF-MS analysis of *P. umbilicalis* and *U. lactuca*.

VOCs	<i>Porphyra umbilicalis</i> (PU)			<i>Ulva lactuca</i> (UL)		
	CTRL	MAP	VAC	CTRL	MAP	VAC
Day 0	a, A	a, A	a, A	a, A	a, A	a, A
Day 3	ab, A	ab, A	ab, A	a, A	b, B	b, B
Day 6	b, A	b, A	b, A	a, A	b, B	b, B
Day 9	ab, A	ab, A	ab, A	a, A	b, B	b, B
Day 12	ab, A	ab, A	ab, A	a, A	b, B	b, B
Day 15	ab, A	ab, A	ab, A	a, A	b, B	b, B

* Notes: Different lowercase letters in the same column are significantly different ($P < 0.05$) throughout storage days. Different uppercase letters in the same row are significantly different ($P < 0.05$) among treatments (for each seaweed).

Table S4. French guidelines that apply to dry seaweed products and Portuguese guidelines that apply to “minimally processed” food products [1,2].

Microorganisms / Pathogens	French Guidelines Limits (CFU.g ⁻¹)	Portuguese Guidelines Limits (CFU.g ⁻¹)
Aerobe mesophiles (30 °C)	≤ 10 ⁵	≤ 10 ⁶
Yeasts	*****	≤ 10 ⁵
Molds	*****	≤ 5x10 ²
Enterobacteriaceae (37 °C)	*****	≤ 10 ⁵
Coliforms (fecal) / <i>E. coli</i>	≤ 10	≤ 10 (N/D)
Anaerobe Sulfite Reducers	≤ 10 ²	*****
Coagulase-positive Staphylococci / <i>S. aureus</i>	≤ 10 ²	≤ 10 (N/D)
<i>Bacillus</i> spp.	*****	≤ 10 ⁴
<i>Bacillus cereus</i>	*****	≤ 10 ³
<i>Clostridium perfringens</i>	≤ 1	≤ 10 ²
<i>Listeria</i> spp.	*****	≤ 10 (N/D)
<i>Listeria monocytogenes</i>	*****	Not detected (per 25 g)
<i>Salmonella</i> spp.	Not detected (per 25 g)	Not detected (per 25 g)
<i>Vibrio cholerae</i> , <i>V. parahaemolyticus</i> , <i>Campylobacter</i> spp., <i>Cronobacter</i> spp., <i>Shigella</i> spp., <i>Yersinia enterocolitica</i>	*****	Not detected (per 25 g)

1. CEVA *Macroalgues et Microalgues Alimentaires - Statut Règlementaire En France et En Europe* (Synthèse CEVA 2019); Pleubian, France, 2019;
2. INSA *Interpretação de Resultados de Ensaaios Microbiológicos Em Alimentos Prontos Para Consumo e Em Superfícies Do Ambiente de Preparação e Distribuição Alimentar (Valores-Guia)*; Instituto Nacional de Saúde Doutor Ricardo Jorge: Lisboa, Portugal, 2019;

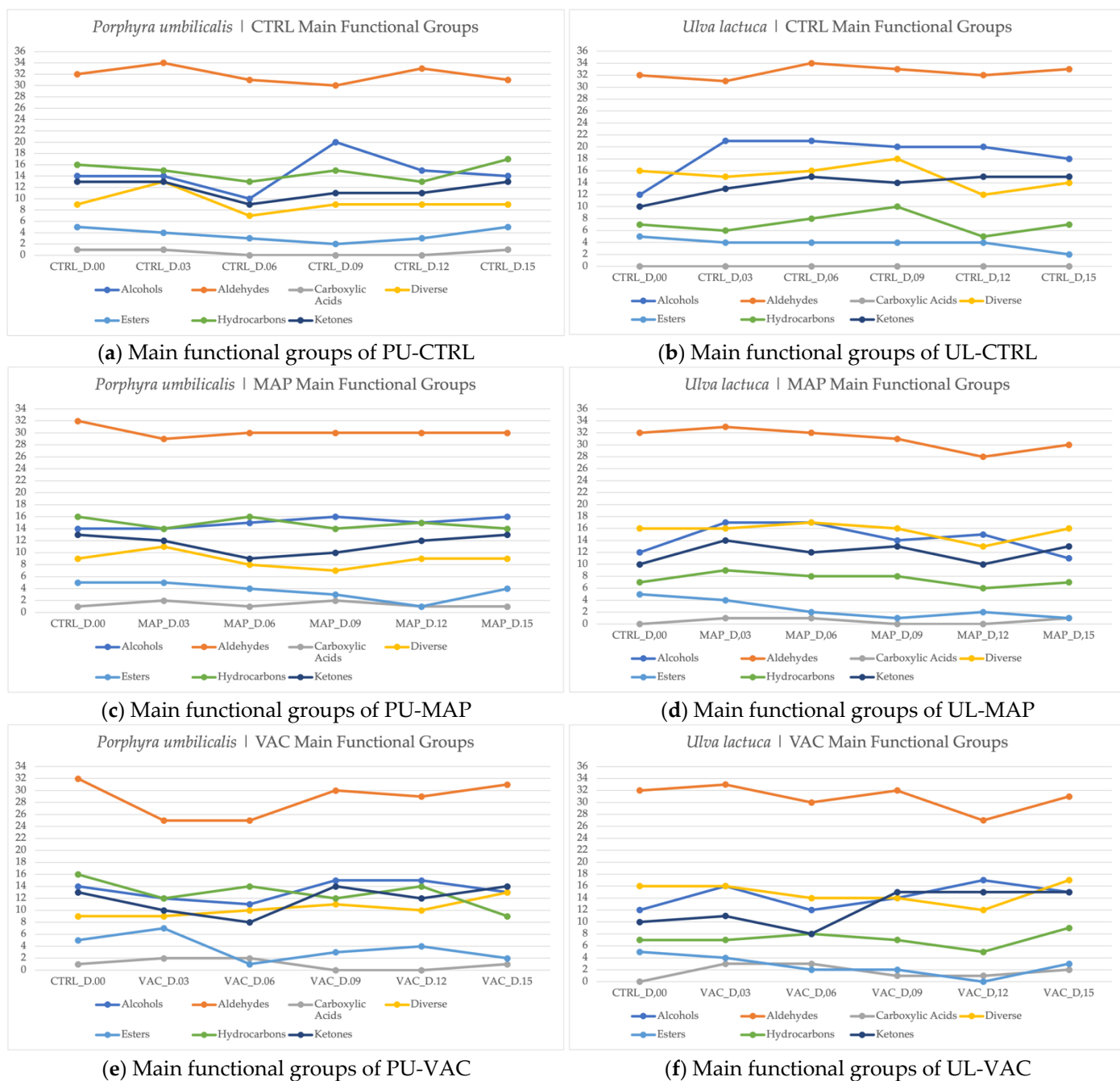


Figure S1. Diversity of VOCs over time in *Porphyrta umbilicalis* and *Ulva lactuca*, grouped by functional groups.

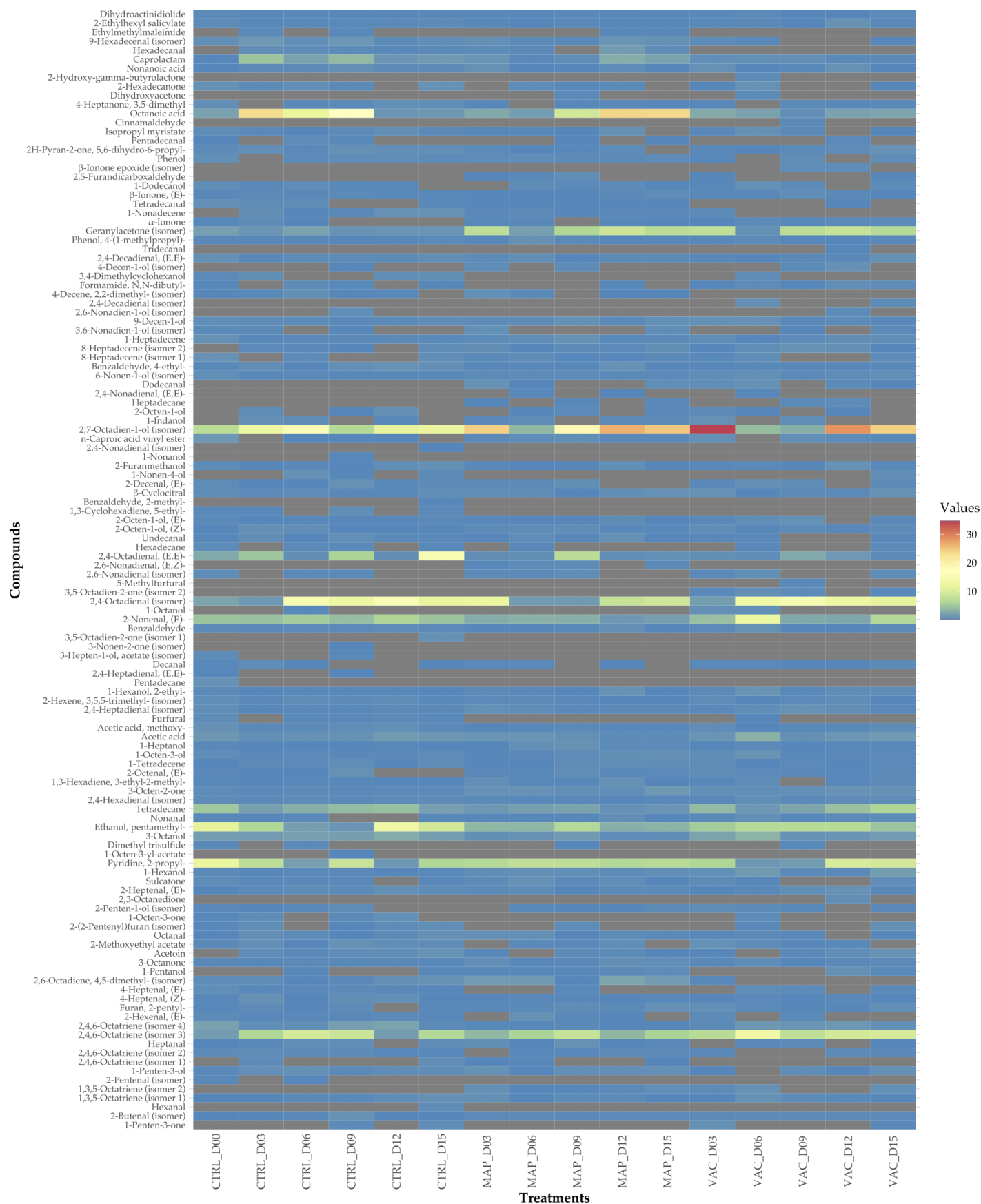


Figure S2. Heatmap graphic with the GC-TOF-MS results for *Porphyrta umbilicalis*

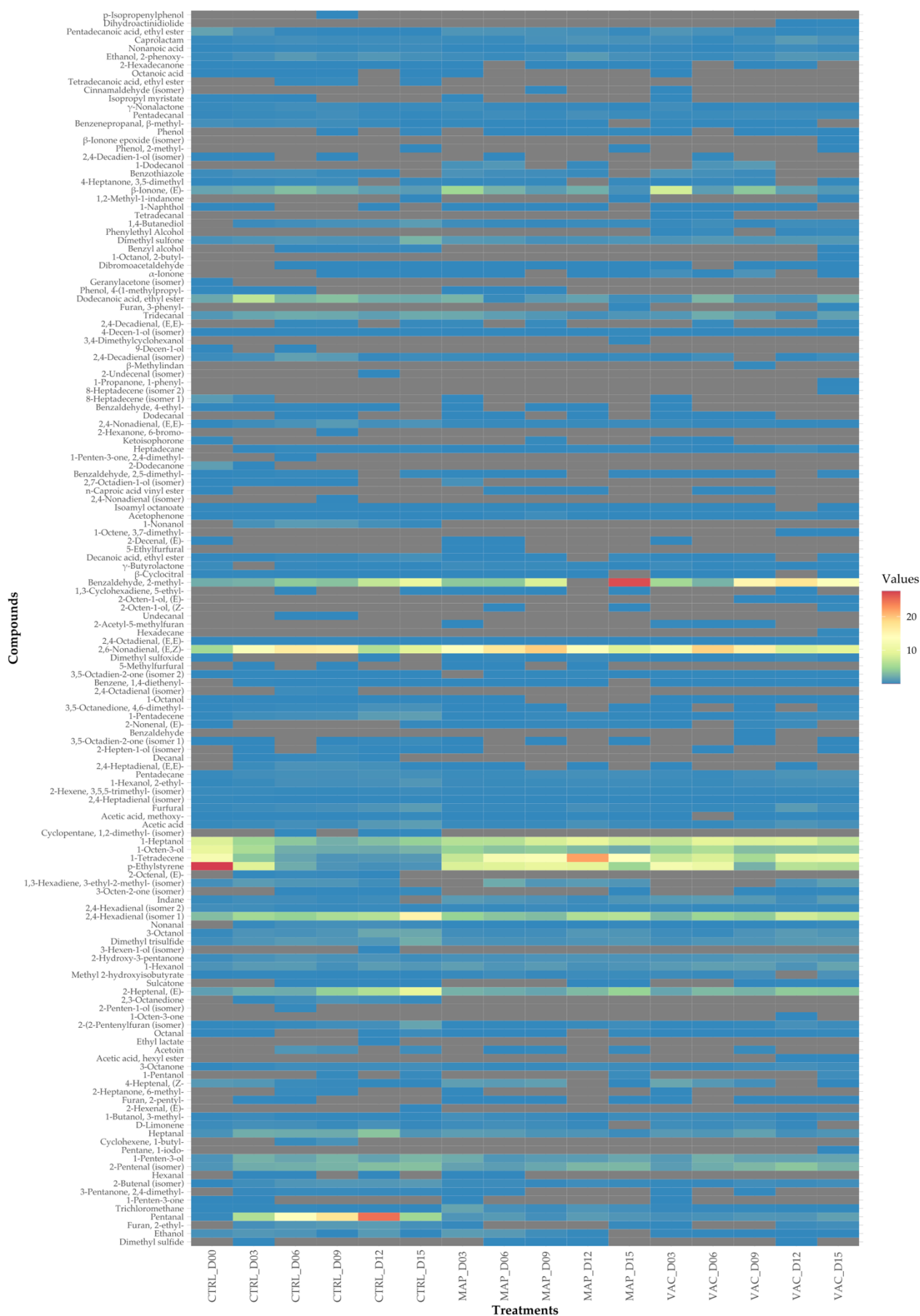


Figure S3. Heatmap graphic with the GC-TOF-MS results for *Ulva lactuca*