Controlling oxidation in skin care products with novel seaweed antioxidants

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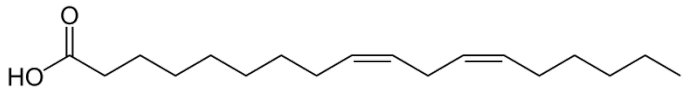
DTU Food
National Food Institute

Product quality and safety issues

Oxidation of functional lipids in skin care products

LH 

↓ Light, heat, metal ions

Lipid radicals (L·) → ↑ oxidative stress; ↑ aging process

↓ Oxygen

Lipid peroxides (LOOH)

↓ Metal ions

Secondary oxidation products (e.g. ketones, aldehydes) →  **Rancid taste and odour**

Costumers demands

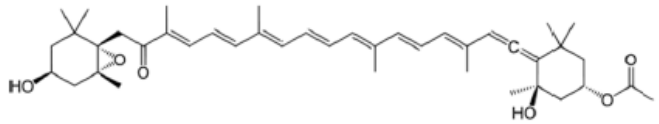
Solution:

development of new natural antioxidants

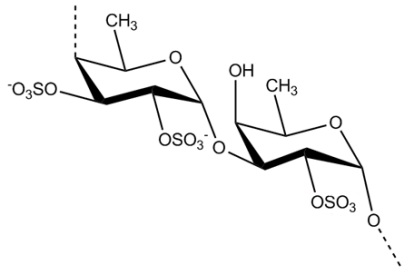
BROWN ALGAE

↓ Extraction of antioxidants

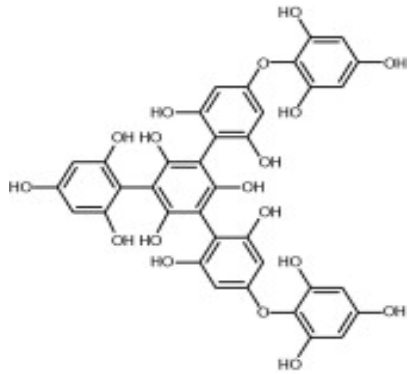
Xanthophylls (fucoxanthin)



Sulphated polysaccharides



Polyphenolic compounds



Result → Healthy and sustainable products

Bioactive compounds

Fucus vesiculosus

vs

Saccharina latissima

Bioactive compounds	*Fucus*	*Saccharina*
Polysaccharides	62-66%	38-61%
Protein	1.4-17%	3-21%
α-Tocopherol	38-73 mg/kg dw	0.1 mg/kg dw
Pigments (fucoxanthin)	340 mg/kg dw	-
Phenolic compounds	0.4-12.2%	0.2-5.3%

Source: Holdt & Kraan, 2011

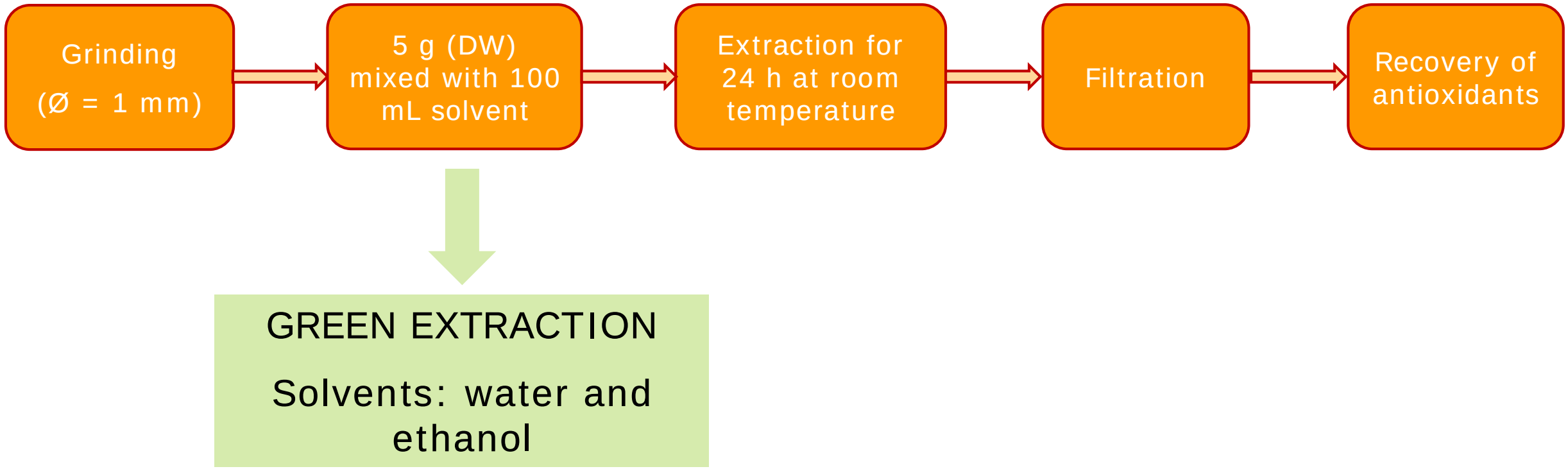
Antioxidant activity?

Studies (S): Extraction of antioxidant from brown algae

Tasks

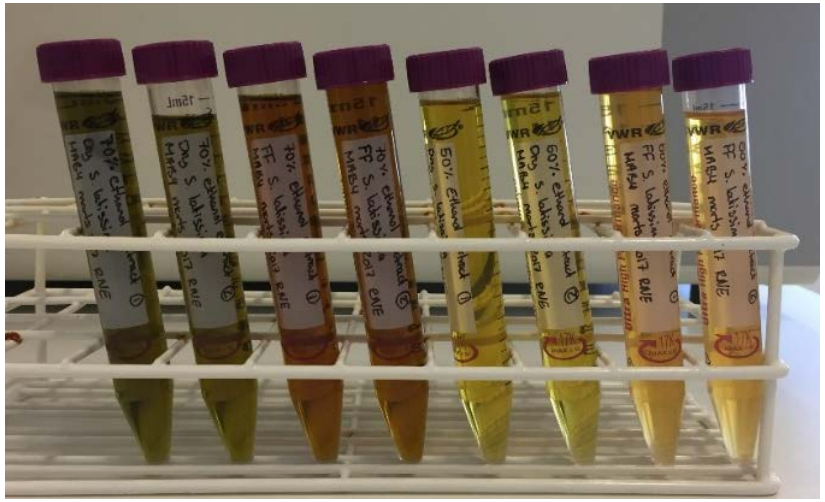
- Extraction of antioxidants from S1) *Fucus vesiculosus* (Danish) and S2) *Saccharina latissima* (Faroes)
- Determine the antioxidant composition of the extracts (major compounds)
- Evaluate the *in vitro* antioxidant properties of the extracts
- Evaluate the antioxidant efficacy of seaweed extracts in skin care model systems (facial cream)

Extraction process (Solid Liquid Extraction)



Extract overview

Study	Seaweed	Solvent	Code
S1	*Fucus vesiculosus*	Water	FWE
		80% ethanol	F80EE
S2	*Saccharina latissima*	Water	SWE
		50% ethanol	S50EE
		70% ethanol	S70EE



S. latissima, 70 and 50 % ethanol extracts

Extract screening

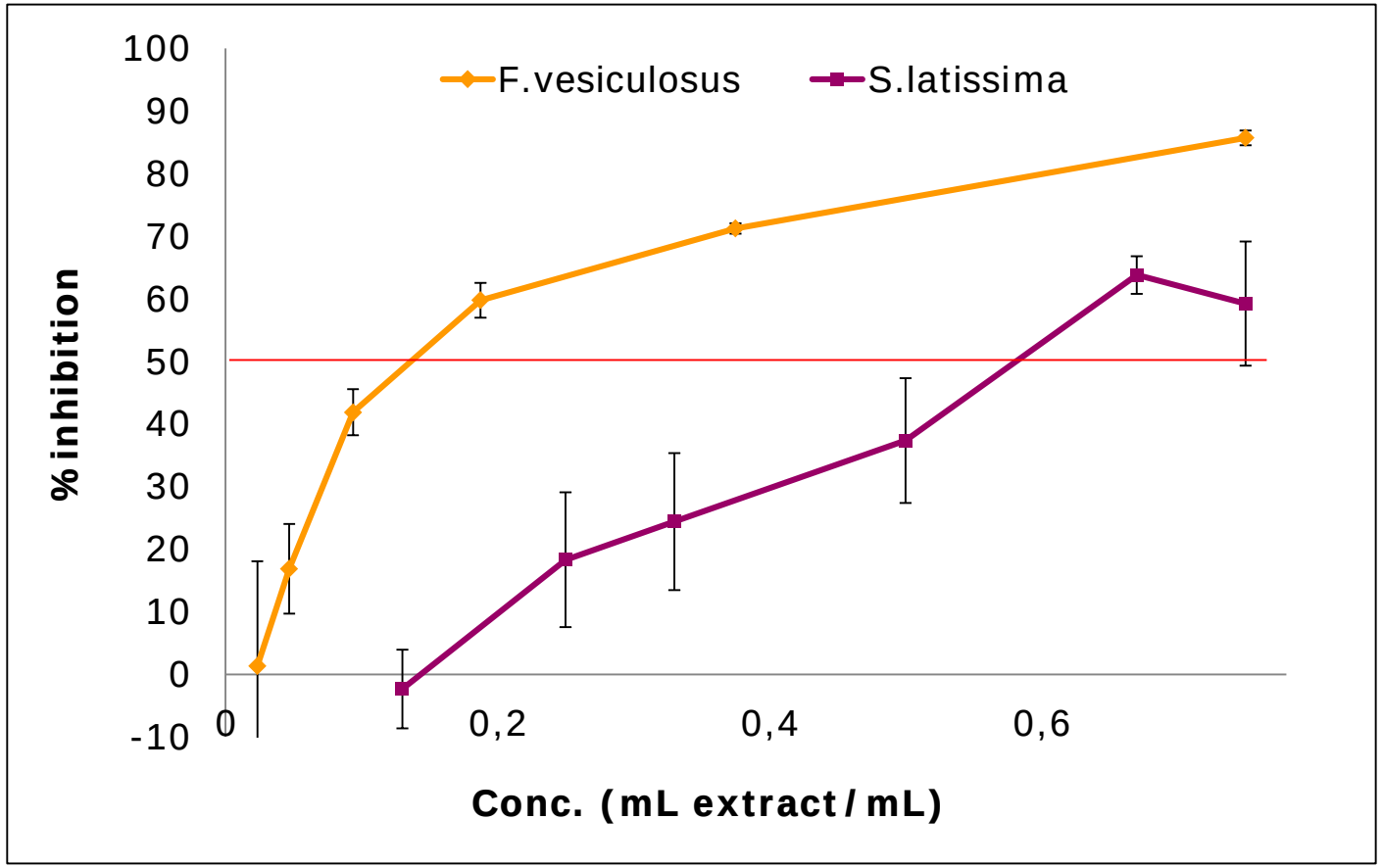
Total phenolic content and antioxidant properties (mean±sd)

			TPC	Metal chelating ability		DPPH radical scavenging capacity		Reducing power	
Seaweed	**Solvent**	**Code**	**TPC (mg GAE/L)**	**EC50 (mL/mL)**	**Imax (%)***	**EC50 (mL/mL)**	**Imax (%)***	**EC0.5 (mL/mL)**	**Imax (Abs)***
Fucus vesiculosus	Water	FWE	867.2±34.9	0.12±0.03	90.7±3.5	$4.2*10^{-3}$±0.2	89.5±3.1	0.4±0.1	1.7±0.2
	80% ethanol	F80EE	830.3±19.8	0.09±0.01	88.3±5.3	$3.7*10^{-3}$±0.1	90.8±3.7	0.4±0.0	1.8±0.1
Saccharina latissima	Water	SWE	160.9±0.3	0.5±0.0	61.6±1.9	0.43	82.6±3.8	ND	0.4±0.0
	50% ethanol	S50EE	141.5±0.3	ND	29.1±7.5	0.34	82.6±3.8	ND	0.7±0.0
	70% ethanol	S70EE	111.8±0.0	ND	51.5±7.6	0.42	76.3±4.7	ND	0.5±0.0

*Undiluted extract solution

Metal chelating ability

F. vesiculosus vs *S. latissima* (water extracts)



Chemical composition
Pigments

	Fucus vesiculosus		*Saccharina latissima*		
Pigments (mg/100 g dw)	**FWE**	**F80EE**	**SWE**	**S50EE**	**S70EE**
Chlorophyl c3	nd	nd	nd	0.3±0.0	35.4±16.6
Chlorophyl c2	nd	6.8±0.7	nd	0.4±0.2	11.7±0.9
19-But-Fucoxanthin	nd	20.2±2.4	nd	nd	6.5±4.2
Fucoxanthin	nd	nd	nd	0.1±0.0	13.6±0.8
Lutein	nd	0.8±0.1	0.2	nd	nd
ß-carotene	nd	0.6±0.4	3.4±0.1	nd	nd

Storage trials

S1
F. vesiculosus added to facial cream formulation

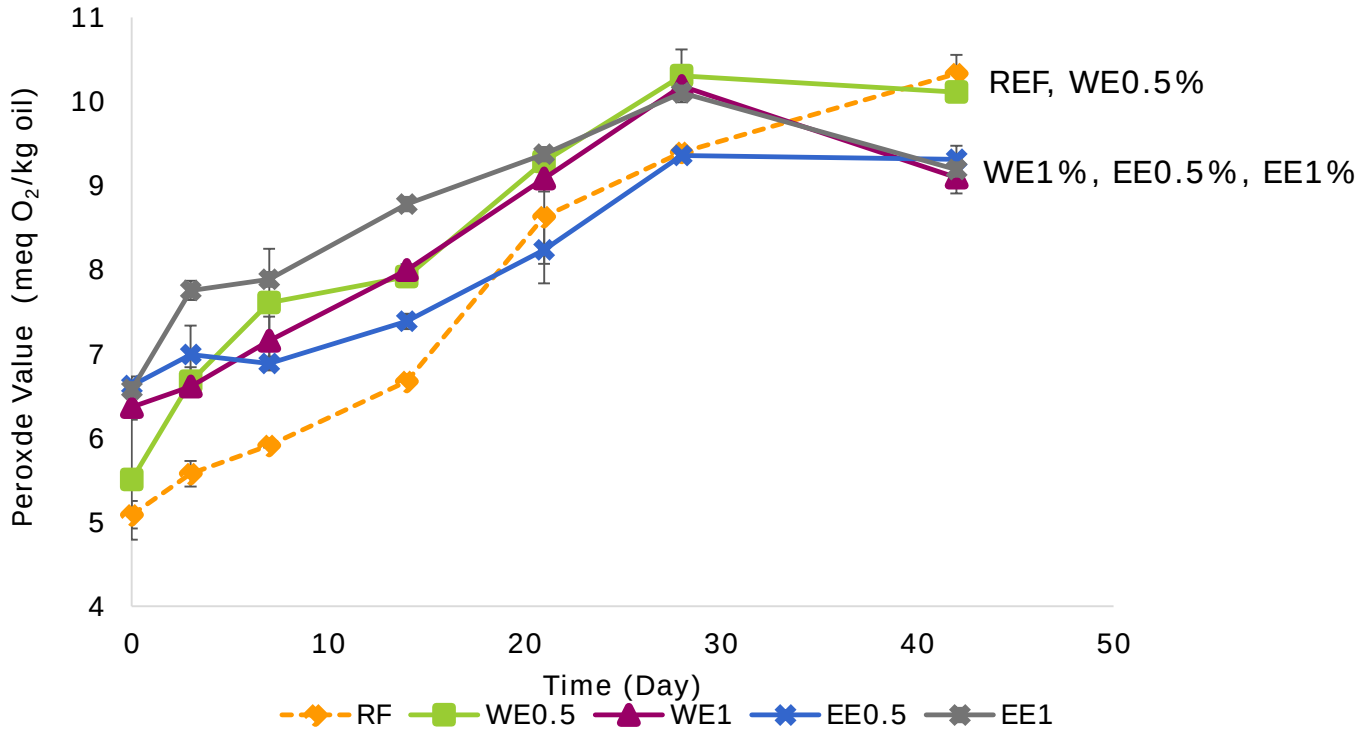
Storage trial S1:

- 0.5 and 1% extract added (water or 80% (v/v) ethanol extract)
    - Samples: WE0.5, WE1, EE0.5 or EE1 (+REF without added extract)
- Storage for 42 days (dark, room temp)
- Determine oxidative stability: i.e fatty acid composition, peroxide value, secondary oxidation products, and tocopherols
- Almond oil and waxes used for the formulation:
    - 18:1: 54 %
    - 18:2: 18 %

S1

F. vesiculosus added to facial cream formulation

Results: Peroxide value



- EE0.5, EE1 and WE1, had a significantly higher PV than REF at day 0
- Maximum PV at day 28 for samples with extracts
- Oxidation rate at day 28:
  - REF>EE0.5, EE1 and WE1

S1
F. vesiculosus added facial cream formulations

Results: Secondary volatile oxidation products

Oxidation rate					
	REF	EE0.5	EE1	WE0.5	WE1
Heptanal	4.92%	-2.12%	1.82%	5.26%	1.04%
Hexanal	15.56%	7.81%	6.82%	15.76%	11.47%
2-Pentylfuran	86.28%	60.01%	72.42%	73.55%	68.25%

- Generally EE0.5 and EE1 had a lower oxidation rate compared with REF and cream added FWE
- Antioxidation effect
  - EE1>EE0.5>WE1>WE0.5≈REF
  - EE1 showed the lowest oxidation rate for hexanal

S1

F. vesiculosus added facial cream formulation

Total Tocopherol Content			
	Day 0	Day 42	Percentage Change
unit	µg toc/g oil	µg toc/g oil	(%)
REF	5937 ± 307	5072 ± 383	-14.58 %
EE0.5	5155 ± 120	5292 ± 93.5	2.67 %
EE1	5379 ± 167	5440 ± 48.3	1.13 %
WE0.5	5432 ± 95.6	4950 ± 88.7	-8.87 %
WE1	6138 ± 9.66	5264 ± 82.9	-14.14 %

- REF and WE1: significant decrease in TTC between day 0 and 42
- No tocopherol consumption when ethanol extract was added
  - Phenolic compounds used before tocopherols?
  - A synergistic effect between tocopherol and phenolic compounds or pigments?
  - Regeneration of tocopherol?

S2

S. Latissima added to commercial cream

Storage trial S2:

- 0.2 and 2% extract added (water, 50% or 70% (v/v) ethanol extract)
    - Samples: WE0.2, WE2, 50EE0.2, 50EE2, 70EE0.2 or 70EE2 (+CON without added extract)

- Abricot oil used in the creams:
    - 45 % 18:1 n-9
    - 15 % 18:2 n-6

- Storage for 70 days (dark, room temp)

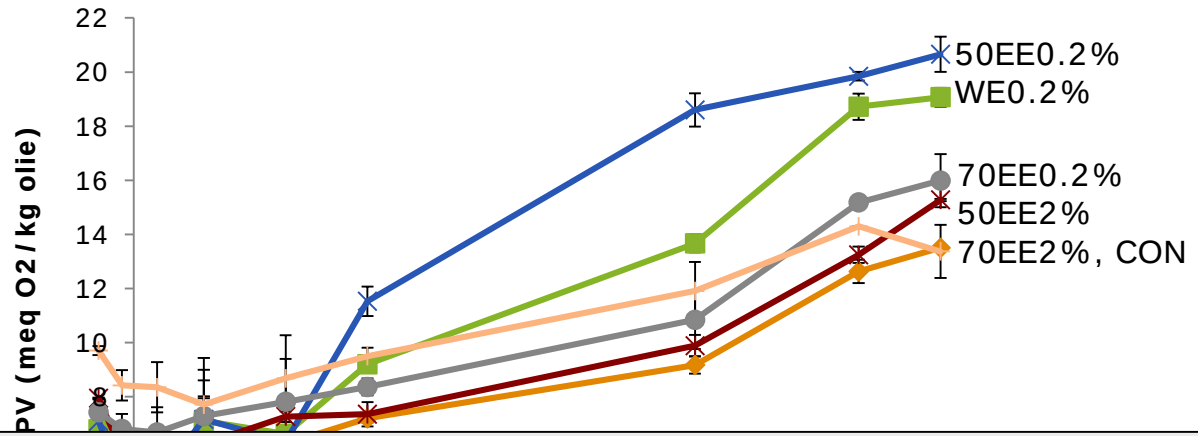
- Determine oxidative stability
    - Fatty acid composition
    - Peroxide value
    - Secondary oxidation products
    - Tocopherol consumption

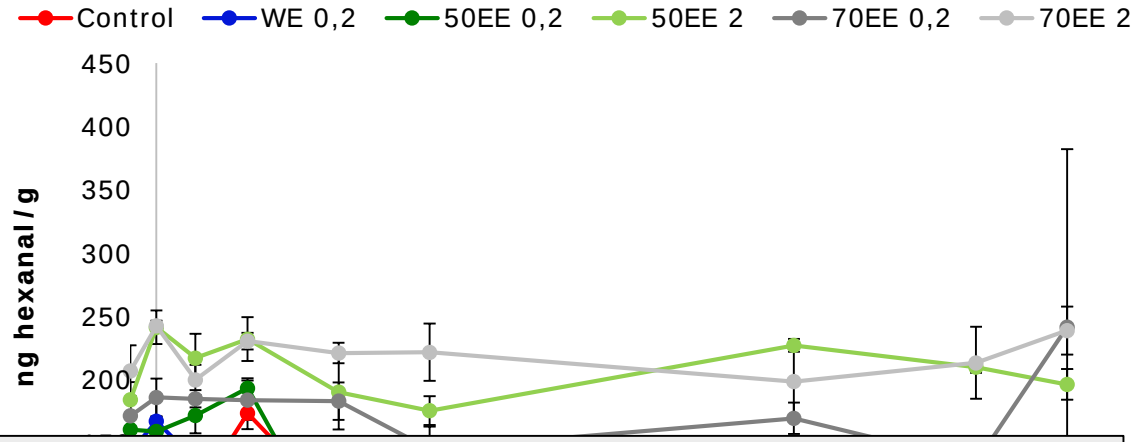
- Microbial contamination of WE2 (not included)

S2

S. Latissima added to commercial cream

Results: Peroxide value and secondary oxidation products (e.g. hexanal)





Preliminary results

→ No antioxidant protection of unsaturated fatty acids compared to control

→ Prooxidant activity towards formation of primary oxidation products?

→ No clear development in secondary oxidation products

→ No consumption of α-tocopherol during storage (not shown)

The cream is stable

Conclusion

- Antioxidant was extracted from both types of seaweed with water and aqueous ethanol solutions using SLE.
- *F. vesiculosus* extracts was higher in TPC and *in vitro* antioxidant capacity compared with *S. latissima*
- Aqueous ethanol solutions extracted fucoxanthin from the seaweed
- Application of *F. vesiculosus* extracts improved the oxidative stability of the facial cream when stored in darkness → decreased formation of primary and secondary oxidation products
- No clear antioxidant activity of *S. latissima* in facial cream (cream itself was stable)
  - Accelerated oxidation studies are needed

Acknowledgement

Susan L. Holdt

Thank you!