Peptides, polyphenols and polysaccharides from *Ulva ohnoi*, *Phyllospora comosa* and *Ecklonia radiata* inhibit ACE-1, α-Amylase and lipase *in vitro* and have potential for use in the management of metabolic syndrome

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Introduction

Hypertension, type-2-diabetes, and obesity are contributory risk factors for metabolic syndrome. There is evidence that these disorders may be ameliorated through the consumption of bioactive peptides, polyphenols and complex polysaccharides which inhibit enzymes involved in the pathways of diseases associated with metabolic syndrome. Peptide hydrolysates (PEP), polyphenol (PP) and polysaccharide (PS) extracts from the Australian seaweeds, *Phyllospora comosa*, *Ecklonia radiata* (Phaeophyceae), and *Ulva ohnoi* (Chlorophyceae) were assessed for inhibitory activities *in vitro* against Angiotensin-I-Converting Enzyme (ACE-1) (to reduce blood pressure), α-amylase (for glycaemic control), and lipase (to reduce dietary fat absorption) using established assay methods.

Methods

POLYSACCHARIDES
→ Lipid removal, enzyme hydrolysis, precipitation of polysaccharides [1]
→ Soluble & insoluble fibre quantification

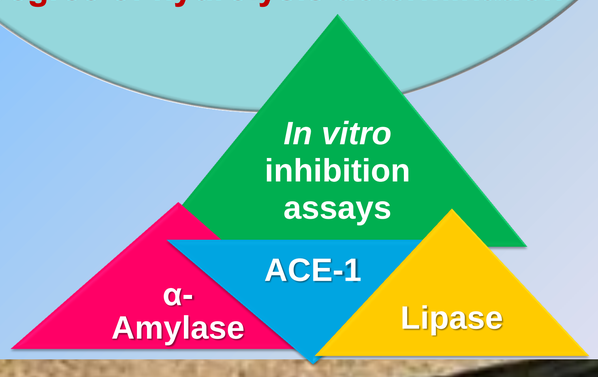
POLYPHENOLS
→ Lipid removal, acetone:H_2O (70:30 v/v) extraction cellulose/toluene purification (phlorotannins)[2]
EtOH:H_2O (96:4 v/v) extraction (*U. ohnoi* polyphenols)[3]
→ Total phenolic content assay

PROTEIN
→ Ultrasonication with H_2O & ammonium sulphate precipitation [4,5]
→ Enzymatic hydrolysis [4]
→ Molecular weight cut off (MWCO) filtration of hydrolysates
→ Degree of hydrolysis determination [6]

P. comosa

U. ohnoi

E. radiata



Results

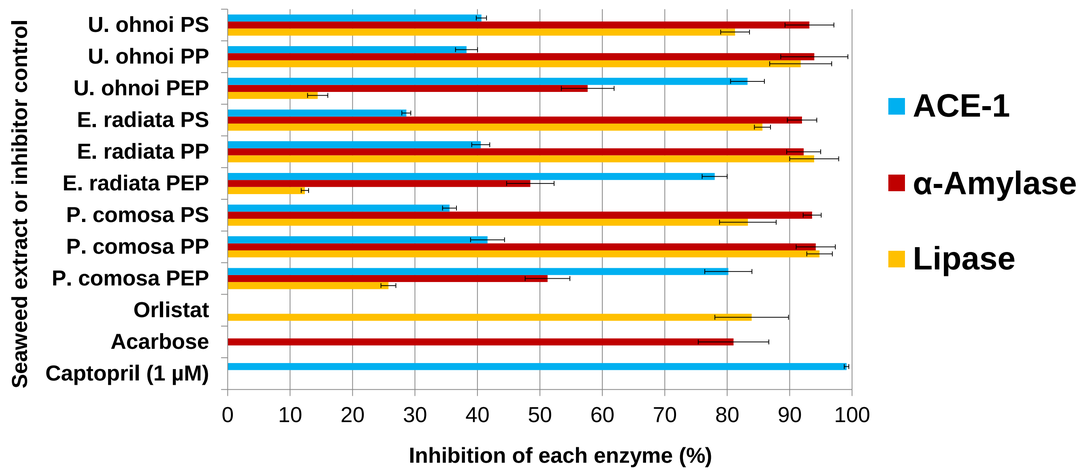


Fig. 1. Percentage inhibition of ACE-1, α-Amylase and lipase by seaweed extracts, and controls Acarbose & Orlistat (all assayed at 1 mg/mL) and Captopril© (assayed at 1 µM/mL)

Table 1. Half-maximal inhibitory concentration (IC_{50}) of seaweed extracts and control inhibitors (mean ± STD)

	IC_{50} (µg/mL^{-})		
Species and extract type	ACE-1	α-Amylase	Lipase
P. comosa PEP	198.23 ± 13.54 ^{c}	487.73 ± 15.62 ^{f}	742.48 ± 30.37 ^{g}
P. comosa PP	583.76 ± 9.42 ^{e}	58.31 ± 1.41 ^{a}	52.14 ± 2.77 ^{a}
P. comosa PS	644.70 ± 15.08 ^{g}	63.94 ± 5.79 ^{a}	166.91 ± 5.03 ^{e}
E. radiata PEP	220.09 ± 2.78 ^{d}	515.24 ± 10.53 ^{g}	876.30 ± 34.92 ^{hi}
E. radiata PP	594.65 ± 20.63 ^{e}	77.48 ± 4.38 ^{c}	60.72 ± 9.50 ^{b}
E. radiata PS	713.84 ± 12.45 ^{h}	80.16 ± 3.64 ^{c}	143.59 ± 6.39 ^{d}
U. ohnoi PEP	167.52 ± 3.17 ^{b}	423.39 ± 18.60 ^{e}	855.89 ± 22.06 ^{h}
U. ohnoi PP	617.46 ± 28.51 ^{f}	60.58 ± 5.37 ^{a}	62.27 ± 7.62 ^{b}
U. ohnoi PS	593.57 ± 36.49 ^{e}	68.32 ± 5.73 ^{b}	187.40 ± 12.43 ^{f}
Captopril©	8.87 ± 0.04 ^{a}	/	/
Acarbose	/	89.90 ± 0.15 ^{d}	/
Orlistat	/	/	70.83 ± 0.07 ^{c}

Table 2. Degree of hydrolysis of whole hydrolysates (mean ± STD)

	DH (%)
P. comosa PEP	58.93 ± 2.10 ^{a}
E. radiata PEP	60.26 ± 2.89 ^{a}
U. ohnoi PEP	69.72 ± 4.06 ^{b}

All PS and PP extracts had significantly lower, more effective IC_{50} values than Acarbose, while all PP extracts were significantly lower than Orlistat. ACE-1 IC_{50} concentrations of seaweed extracts ranged from 167.52 ± 3.17 µg/mL (*U. ohnoi* PEP) to 713.84 ± 12.45 µg/mL (*E. radiata* PS), but were not as effective as Captopril (8.87 ± 0.04 µg/mL). Similar inhibitory values for other species of the genera Ecklonia and Ulva [7,8,9] have been reported; however, to the authors' knowledge there are no published values for *P. comosa*, *U. ohnoi* or *E. radiata* ACE-1, α-amylase, or lipase inhibitory activities.

Conclusion

This study shows that select seaweed-derived peptides, polysaccharides and polyphenols can inhibit enzymes associated with metabolic syndrome *in vitro*, and suggests they have potential for use as functional food ingredients in the management of metabolic disorders. Future work will involve characterisation of the individual polysaccharides including fucoidan, laminarin, alginate and ulvan, the individual phlorotannins such as eckol and fuhalols, as well as the amino acid sequencing of the peptides within the hydrolysates. Although clinical trials are required to evaluate *in vivo* efficacy, the data from this study may inform future studies using these three edible seaweeds for functional food use as antihypertensive, antidiabetic, and weight control ingredients.

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