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Development Of New Functional Food Applications Of Edible Irish Seaweed

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Development of new functional food applications of edible Irish seaweed

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INTRODUCTION

- Seaweeds belong to a group of marine plants known as algae and are known as a source of bioactive compounds including antioxidants and antimicrobials, as they contain secondary metabolites characterized by a broad spectrum of biological activities
- Seaweeds are exposed to light and high oxygen concentrations which result in free radicals and other strong oxidizing agents being formed, however, they seldom suffer any serious photodynamic damage. This implies that their cells have protective mechanisms and compounds
- Based on nutrient and chemical composition seaweeds are classified as Rhodophyta (red algae), Phaeophyta, (brown algae) and Chlorophyta (green algae)
- Ireland harvests 32,000 tonnes of seaweed per year with an annual turnover of €15 million
- Seaweeds are a relatively unexploited resource in Ireland, therefore the main objectives of this work were to:

(A) Evaluate and compare the antioxidant and antimicrobial activity of six species of edible Irish seaweeds

(B) Investigate the effect of processing on *Himanthalia elongata*

(C) Analyse the drying process of *H. elongata*

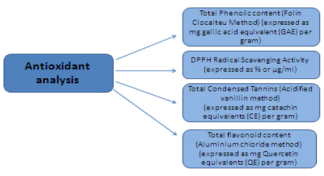
MATERIALS AND METHODS

Raw material: seaweed species used were

EXTRACTION METHOD

- 5g seaweed crushed with liquid nitrogen
- Extraction with 50ml of 60% methanol
- Flushed with nitrogen for 1 min
- Shaken at 100 rpm 40°C for 2 hours
- Filtered and rotary evaporated to dryness

ANTIOXIDANT ANALYSIS

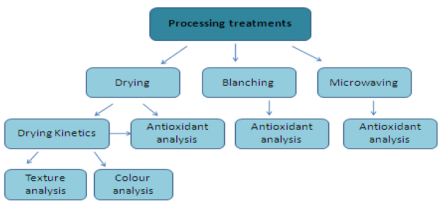


ANTIMICROBIAL ANALYSIS

96-well microtitre method : Quantitative analysis

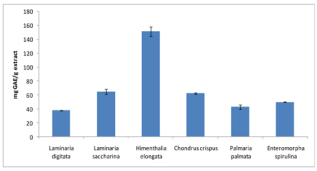
Common food spoilage and food pathogenic bacteria used	Type of bacteria
Listeria monocytogenes	Gram+ Food pathogenic bacteria
Salmonella abony	Gram- Food pathogenic bacteria
Enterococcus faecalis	Gram+ Food spoilage bacteria
Pseudomonas aeruginosa	Gram- Food spoilage bacteria

PROCESSING OF *H. ELONGATA*



RESULTS AND DISCUSSION

(A) Antioxidant and antimicrobial activity of six species of Irish edible seaweeds



⇒ *H. elongata* had the highest total phenolic content, the most effective DPPH radical scavenging and antimicrobial activity among the six species of studied seaweeds

Fig. 1. Total phenolic content of seaweed extracts

Table 1. DPPH radical scavenging activity of seaweed extracts

Species	Activity at 100µg/ml concentration (%)	EC_{50} (µg/ml)
Laminaria digitata	56.2	10
Laminaria saccharina	56.7	10
Himanthalia elongata	65.5	1
Chondrus crispus	52.2	5
Palmaria palmata	53.6	25
Enteromorpha spirulina	51.0	50
Ascorbic acid	96.9	1

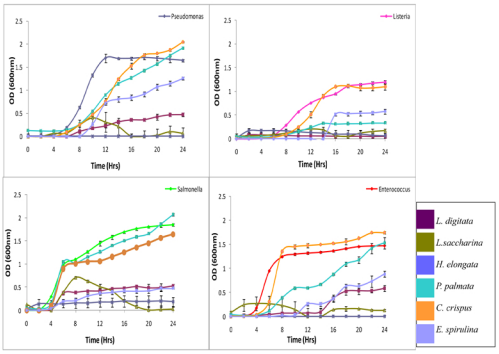


Fig. 2. Kinetic analysis of highest concentration of seaweed extract against common food spoilage and food pathogenic bacteria

(B) Processing of *H. elongata*

- This study was conducted as a preliminary screening to investigate the effects of various food processing methods on the phytochemical constituents of *H. elongata*
- Hydrothermal processing was carried out until an edible texture was achieved as was pre-determined by a sensory panel

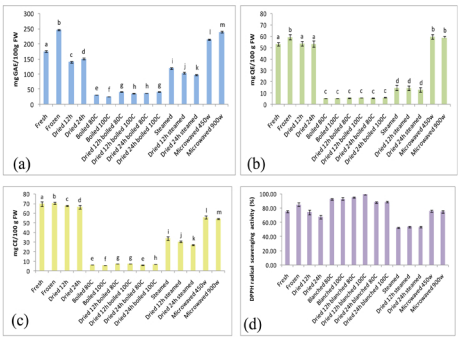


Fig. 3. Effect of processing treatments on the (a) total phenolic content, (b) total flavonoids, (c) total condensed tannins and (d) DPPH radical scavenging activity (concentration 50µg/ml) of *H. elongata* (per 100g FW)
FW: fresh weight

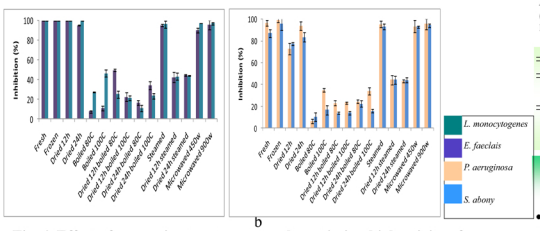


Fig. 4. Effect of processing treatments on the antimicrobial activity of (a) *L. monocytogenes* and *E. faecalis (Gram+)* and (b) *S. enterica* and *P. aeruginosa (Gram-)* of highest concentration of seaweed extract

⇒ The method of processing significantly influences the concentrations of antioxidants and antimicrobials
⇒ Palatability of *H. elongata* is dependant on some heat treatment in order to achieve an edible texture, therefore cooking invariably leads to a loss of antioxidant properties
⇒ A combination of drying followed by boiling reduced cooking time and led to less leaching of phytochemicals

RESULTS AND DISCUSSION

(C) Drying of *H. elongata* and Modelling

Drying conditions: 25, 30, 35 and 40°C over 24 hours

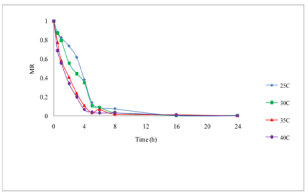


Fig. 5. Experimental drying curves of *H. elongata* at different temperatures

Models applied:

Newton: MR = exp(-kt) **Logarithmic**: MR = a exp(-kt) + c **Henderson-Pabis**: MR = a * exp(-kt)

MR: moisture ratio

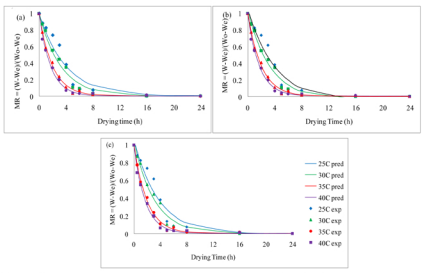


Fig. 6. Experimental and Predicted drying curves for (a) Newton and (b) Logarithmic model and (c) Henderson-Pabis model for the four working temperatures

Table 2. Results of fitting of drying kinetics to the Newton, Logarithmic model and the Henderson-Pabis (values in brackets are the standard error for the parameters)

		25°C	30°C	35°C	40°C
Newton	k	0.254 (±0.03)	0.313 (±0.02)	0.504 (±0.02)	0.591 (±0.017)
Logarithmic	a	1.103 (±0.089)	1.065 (±0.05)	1.0 (±0.025)	0.976 (±0.025)
	k	0.247 (±0.048)	0.305 (±0.03)	0.499 (±0.032)	0.581 (±0.037)
	c	-0.05 (±0.07)	-0.03 (±0.04)	-0.002 (±0.015)	0.003 (±0.01)
Henderson-Pabis	a	1.058 (±0.067)	1.038 (±0.04)	0.998 (±0.057)	0.978 (±0.02)
	k	0.271 (±0.036)	0.326 (±0.026)	0.503 (±0.02)	0.576 (±0.03)

*k, a and c are the model parameters

Table 3. Statistical indices upon modelling the drying of *H. elongata* at a range of drying temperatures

	Temperature (°C)	SSE	RMSE	χ^2	R^2
Newton	25	0.008	0.088	0.009	0.9434
	30	0.003	0.051	0.003	0.9794
	35	0.0005	0.023	0.0006	0.9794
	40	0.0006	0.024	0.0006	0.9943
Logarithmic	25	0.007	0.082	0.009	0.9515
	30	0.002	0.046	0.003	0.9832
	35	0.0005	0.023	0.0007	0.995
	40	0.0005	0.023	0.0007	0.9948
Henderson-Pabis	25	0.007	0.085	0.009	0.948
	30	0.002	0.049	0.003	0.9814
	35	0.0005	0.023	0.0007	0.995
	40	0.0005	0.023	0.0006	0.9948

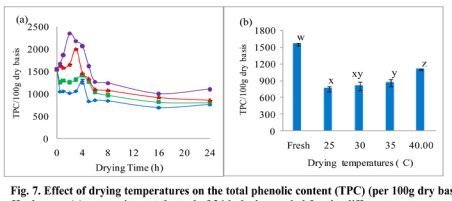


Fig. 7. Effect of drying temperatures on the total phenolic content (TPC) (per 100g dry basis) of *H. elongata* (a) comparison at the end of 24 h drying period for the different temperatures and (b) variation in the phenolic content over the entire drying period
Different letters above the bars indicate significant differences

⇒ Drying kinetics of seaweeds can be accurately predicted using the empirical models above
⇒ Moisture transfer can be described by diffusion and the temperature dependence of the effective moisture diffusivities was shown to follow an Arrhenius relationship
⇒ A reduction of 29% in total phenolic content and 30% in the total flavonoids was seen when *H. elongata* was dried at 40°C. However, an important increase of 41% in total phenolics was observed when the seaweed was dried up to 50% moisture content

CONCLUSIONS

- *H. elongata* contained the highest levels of antioxidants and antimicrobials
- Food processing led to significant loss in antioxidant and antimicrobial activity per 100g FW but the potency of the extract was stronger per gram than fresh
- Drying at 40°C for 2 hours increased the total phenolic content by 41%

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