Biorefinery processes for the valorisation of residual green seaweeds in Galicia

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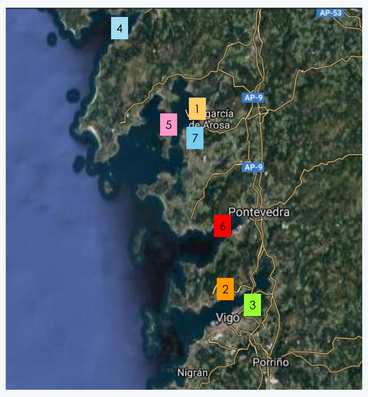
Introduction

The H2020 ALEHOOP project aims to demonstrate at pilot scale the feasibility of recovering low-cost dietary proteins from both algae-based and plant-based sources, namely seaweed and legume production by-products, using biorefineries. Due to green seaweed blooms, highly abundant in Galician Rías Baixas (Spain), several problems are caused in bivalve harvesting areas and therefore, to avoid their mortality, seaweeds need to be removed. Although are commonly managed as urban waste, seaweeds are, in some cases, discharged nearby the coast. The studies carried out in ALEHOOP project sheeted that more than 3.000 tons of seaweeds residues are collected in Galicia each year.

Objective: The present work aimed the extraction of protein from green residual seaweeds, by using enzymatic hydrolysis, to be used as feed in fish diets..

Material and methods

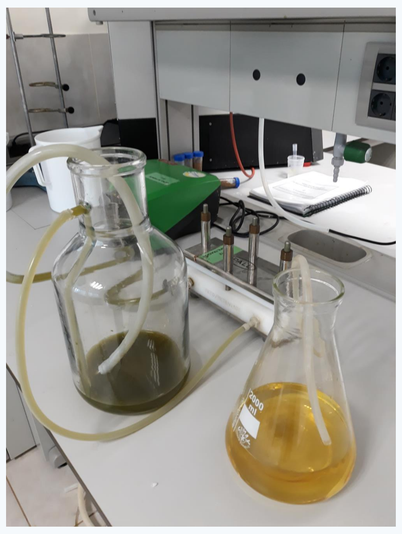
Raw material: Seaweed samples were supplied for different fisherman associations of Galician Rías Baixas (NW of Spain).



Extraction: The extraction of protein was carried out by enzymatic hydrolysis, using different commercial proteases and carbohydrases, in 5 and 10l reactors. After the removal of solids by centrifugation and filtration, the extracts were fractionated by ultrafiltration(UF) and the resulting fractions were dried using a convective oven (concentrate) and a spray dryer (permeate).

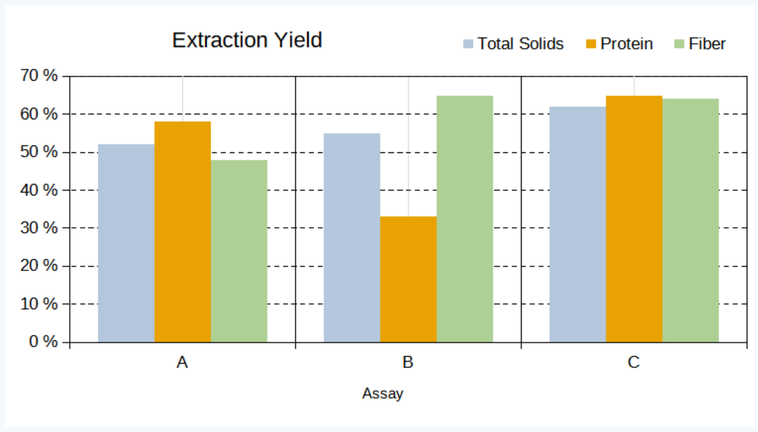
Physico-chemical and microbiological properties of the different samples of seaweeds analyzed

Fisherman Association		1	1	2	2	3	3	3	4	5	5	5	7	5	6
Main Specie		*Ulva lactuca*		*Enteromorpha intestinalis*		*Enteromorpha intestinalis*			*U. Lactuca*	*E. intestinalis*	*U. Lactuca*	*U. Fasciata*	*U. Fasciata*	*U. Lactuca*	*U. Lactuca*
Humidity		88%	81%	80%	50%	67%	77%	68%	78%	73%	86%	86%	88%	80%	79%
Protein		1,3%	1,7%	1,0%	0,9%	1,4%	1,3%	1,0%	2,5%	0,7%	1,2%	1,0%	1,0%	1,0%	2,2%
Fats		0,04%	0,04%	0,10%	0,12%	0,14%	0,05%	0,09%	0,16%	0,09%	0,01%	0,05%	0,01%		0,1%
Ash		7,4%	11,7%	15,5%	46,0%	27,0%	16,0%	27,0%	12,9%	22,0%	6,3%	5,7%	4,2%	11,3%	7,0%
Carbohidrates		0,9%	0,3%	1,1%	1,1%	1,8%	1,8%	1,3%	1,8%	1,8%	1,6%	1,9%	5,0%	1,8%	3,6%
Dietary fiber		2,3%	5,2%	2,3%	1,9%	2,6%	3,8%	2,7%	4,6%	2,4%	4,9%	5,4%	1,7%	5,8%	8,1%
Cd	mg/kg	0,011	<0,010	0,54	0,45	0,055	0,029	0,034	0,025	0,013	<0.010	<0.010	<0,010	<0.010	<0,010
Pb	mg/kg	0,23	0,3	7,9	10	7,4	3,1	6,3	0,24	1,2	0,36	0,52	0,18	0,32	0,13
As	mg/kg	0,73	0,78	1,9	1,9	2,0	1,2	1,6	0,99	1,3	0,57	0,93	0,63	0,71	0,71
Hg	mg/kg	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,10	<0,1	<0,1
I	mg/kg	7,5	6,0	15,8	4,6	25,2	17,7	14	11,1	12,2	2,03	2,7	5,4	4,2	12,8
Aerobios	ufc/g	$8{,}3{\cdot}10^3$	$5.7{\cdot}10^3$	$4{,}1{\cdot}10^5$	$>4{,}9{\cdot}10^5$	$>4{,}9{\cdot}10^6$	$>4{,}9{\cdot}10^6$	$1{,}9{\cdot}10^5$	$<4{,}9{\cdot}10^6$	$3{,}7"{\cdot}10^3$	$4.4{\cdot}10^3$	$2.9{\cdot}10^4$	$> 4.9{\cdot}10^5$	$> 4.9{\cdot}10^5$	$4.9{\cdot}10^6$
Enterobacteria	ufc/g	45	<10	$>4{,}9{\cdot}10^4$	$2{,}5{*}10^4$	$>4{,}9{\cdot}10{*}4$	$4{,}9{\cdot}10^4$	$3{,}7{\cdot}10^3$	$>4{,}9{\cdot}10^4$	$>4{,}9{\cdot}10^4$	$5.0{\cdot}10^3$	$2.1{\cdot}10^4$	$> 4.9{\cdot}10^4$	$> 4.9{\cdot}10^4$	$> 4.9{\cdot}10^4$
Coliformes	ufc/g	44	<10	$6{,}0{\cdot}10^3$	$1{,}3{\cdot}10^3$	$>4{,}9{\cdot}10{*}4$	$3{,}0{\cdot}10^4$	$3{,}9{\cdot}10^3$	$>4{,}9{\cdot}10^4$	$5{,}1{\cdot}10^3$	$1.9{\cdot}10^2$	$1.7{\cdot}10^4$	$3.4{\cdot}10^3$	$3.7{\cdot}10^4$	$4{,}6{\cdot}10^2$
E coli	ufc/g	<10	<10	$1{,}8{\cdot}10^2$	83	$1{,}1{\cdot}10^3$	$1{,}2{\cdot}10^4$	33	$6{,}8{\cdot}10^3$	$1{,}8{\cdot}10^3$	< 10	< 10	< 10	< 10	$2{,}6{\cdot}10^2$
Salmonella	ufc/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Listeria	ufc/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Detected	ND	Detected



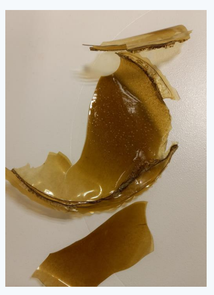
Results

Extraction yields: The use of a protease is needed to achieve a good protein extraction yield. The addition of a carbohydrase increased the fiber extraction yield, but its use does not justify the higher cost operation (reaction times, temperature inactivation) in terms of protein extraction yield.



Experimental conditions

Assay	Protease	Carbohydrase	Reaction time
A	YES	NO	2h
B	NO	YES	12h
C	YES	YES	2h + 12h



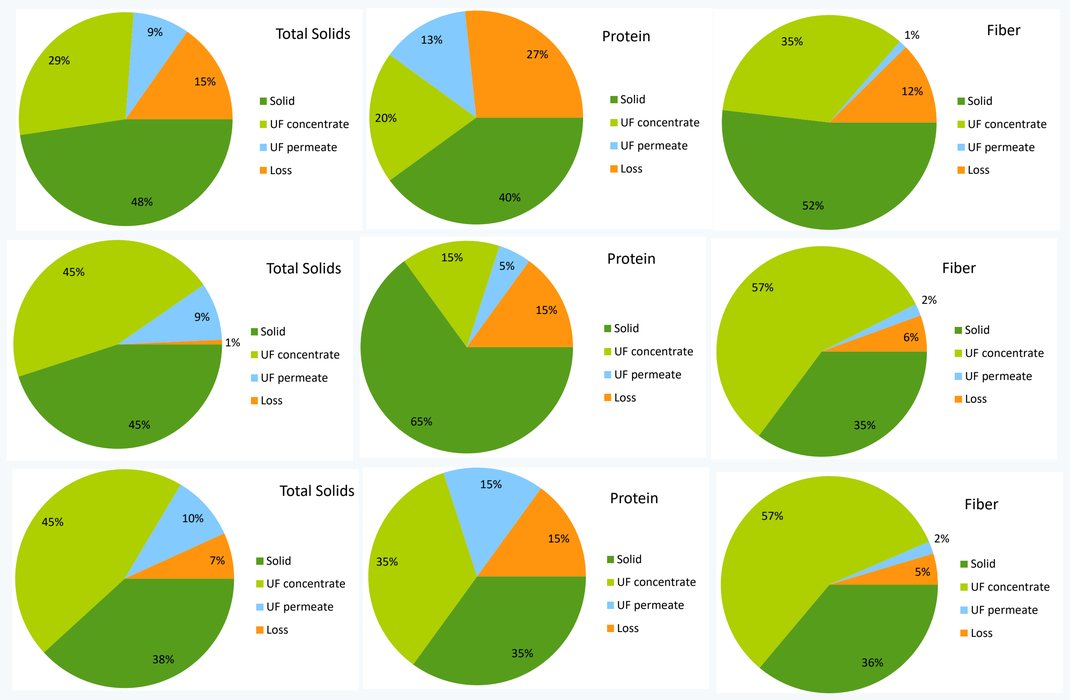
Dried products: UF concentrate (left) and UF permeate (right)

Product characteristics

Assay	UF Product	Protein	Fiber	Ash
A	Concentrate	13,5 %	3,2 %	53 %
	Permeate	5,6 %	47 %	30 %
B	Concentrate	3,3 %	7,9 %	67 %
	Permeate	2,6 %	49 %	34 %
C	Concentrate	11,9 %	7,0 %	57 %
	Permeate	5,6 %	49 %	32 %

Products characterization: In the assays with a high protein extraction yield, the UF permeate product had a higher protein content, however, further process is needed to remove the salts. The UF concentrate product had a high content of dietary fiber, but the salts content is still high. A further diafiltration process could get a more fiber-rich product but the high viscosity of this stream is an important issue for the use of membranes.

Mass balances: Taking into account the characteristics of the inputs and outputs in the biorefinery process, Total Solids, protein and fiber balances were carried out for the assays A, B and C. The extracted protein is distributed in the concentrate (>30 kD) and permeate (<30 kD) UF streams, while the fiber is mainly present in the concentrate. The balance shows that there are more losses of protein than fiber, probably due to the higher losses in the spray drying in comparison with the oven drying.



Conclusions:

- A 60% of protein extraction yield from residual green seaweeds can be achieved in a hydrolytic process using proteases.
- The use of a carbohydrase is needed to achieve higher yields of fiber extraction.
- The use of UF allows to separate most of the fiber and a great part of the protein in different products. However, a further desalination process is needed.

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