View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Marine Institute Open Access Repository (OAR)

Marine Research Sub-Programme

(NDP 2007–'13) Series

SeaChange

Casadh na Taoide

Investigation of the Flavouring and Taste Components of Irish Seaweeds

Industry-Led Award, Final Report

Lead Partner: CyberColloids Ltd.

Author: Sarah Hotchkiss

NDP

National Development Plan

Transforming Ireland

Marine Institute

Foras na Mara

The Marine Institute is the national agency which has the following functions:
"to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to research and development that, in the opinion of the Institute, will promote economic development and create employment and protect the marine environment" Marine Institute Act 1991.

Sea Change: A Marine Knowledge, Research & Innovation Strategy for Ireland

Sea Change—A Marine Knowledge, Research & Innovation Strategy for Ireland 2007-2013—was launched in early 2007 and was the outcome of extensive analysis and consultation with government departments, state agencies, industry and the third-level sector. It outlines a vision for the development of Ireland's marine sector and sets clear objectives aimed at achieving this vision, namely to:

1. Assist existing, and largely indigenous, marine sub-sectors to improve their overall competitiveness and engage in activity that adds value to their outputs by utilising knowledge and technology arising from research.
2. Build new research capacity and capability and utilise fundamental knowledge and technology to create new marine-related commercial opportunities and companies.
3. Inform public policy, governance and regulation by applying the knowledge derived from marine research and monitoring.
4. Increase the marine sector's competitiveness and stimulate the commercialisation of the marine resource in a manner that ensures its sustainability and protects marine biodiversity and ecosystems.
5. Strengthen the economic, social and cultural base of marine dependant regional/rural communities.

The Sea Change strategy was developed as an integral part of the government's Strategy for Science, Technology and Innovation (SSTI) and the Marine Institute as the lead implementation agency is working within SSTI policy and with government departments and agencies to deliver on the Strategy.

The Marine Institute managed Marine Research Sub-Programme, one of eight sub-programmes within the Science, Technology and Innovation (STI) Programme of the National Development Plan 2007—2013, targets funding to meet the objectives of the Sea Change strategy.

Over the lifetime of Sea Change, funding will beprovided for:

- Project-Based Awards
  - o Strategic Research Projects
  - o Applied Research Projects
  - o Demonstration Projects
  - o Desk/Feasibility Studies
- Researcher Awards
  - o Strategic Research Appointments
  - o Research Capacity/Competency Building
  - o Post-Doctoral Fellowships
  - o PhD Scholarships
- Industry-Led Research Awards
  - o Company Awards
  - o Collaborative Awards
- Infrastructure Awards
  - o Infrastructure Acquisition
  - o Access to Infrastructure

Further copies of this publication can be obtained from:
Marine Institute, Rinville, Oranmore, Co. Galway, Ireland or www.marine.ie.

© Marine Institute 2010. Cover photograph courtesy of Sarah Hotchkiss, CyberColloids
ISSN: 2009-3195

NDP National Development Plan
Transforming Ireland

Marine Institute
Foras na Mara

SeaChange
Casadh na Taoide

Marine Research Sub-Programme 2007-2013

Industry-Led Award

Investigation of the Flavouring and Taste Components of Irish Seaweeds

(Project Reference: ILA/07/004)

Lead Partner:	CyberColloids
Author:	Sarah Hotchkiss
Project Duration:	01/02/2008 to 31/07/2009

Acknowledgments

This project (Grant-Aid Agreement No. ILA/07/004) was carried out under the Sea Change Strategy with the support of the Marine Institute and the Marine Research Sub-Programme of the National Development Plan 2007–2013.

Disclaimer

Responsibility for the information and views presented in this report rest solely with the authors and do not necessarily represent those of the Marine Institute. Neither the authors nor Marine Institute accept any responsibility whatsoever for loss or damage occasioned or claimed to have been occasioned, in part or in full, as a consequence of any person acting, or refraining from acting, as a result of a matter contained in this publication.

SeaChange
Casadh na Taoide

NDP
National Development Plan 2007 - 2013

Marine Institute
Foras na Mara

Table of Contents

1. PROJECT SUMMARY

Irish seaweed is an under exploited, naturally nutritious food which is being labelled as a "super food" (Ito & Hori 1989[1], MacArtain et al 2007[2], Warrand 2006[3]). In Asia, seaweed comprises up to 20% of the diet and is recognised not only for its nutritional benefits but also for its unique flavours. In the west, seaweed has yet to find widespread use. Although traditionally eaten for centuries in many European cultures, including Ireland, seaweed still invokes a negative perception when associated with food and in general, the unique flavours of seaweed are not readily accepted. Even the most health conscious of consumers will not compromise when it comes to taste (Bord Bia 2007[4]).

CyberColloids recognised a significant commercial opportunity to develop high-value food products from Irish seaweed that were not only nutritious but tasty and appealing to western consumers. To realise this opportunity however, the company needed to engage in new research, fundamental to which was the ability to assess and utilise the flavour components of edible Irish seaweeds.

The current project targeted the acquisition of new knowledge and the development of new skills to enable CyberColloids to produce commercially attractive, seaweed derived, flavour ingredients for the food industry. Five core areas of research were developed, each with specific objectives and deliverables:

- Building a knowledge base on flavour within CyberColloids;
- Building a capability to assess taste and flavour;
- Formulating product concepts ;
- Developing cooking & processing methodologies; and
- Designing a range of finished products with view to commercialisation.

At the outset, the project needed to build an understanding of the science behind flavour development and enhancement in seaweeds; to identify the components in seaweed important for taste and flavour and also to understand how various cooking and simple processing techniques could affect the development and modification of flavour. This work was carried out through critical review of the literature.

[1] Ito, K. and Hori, K. (1989). Seaweed: chemical composition and potential food uses. Food reviews international. 5(1): 101-144.
[2] Warrand, J. (2006). Healthy polysaccharides. /Food technology and Biotechnology. 44(3): 355-370.
[3] MacArtain, P, Gill, C., Brooks, M., Campbell, R. & Rowland, I. (2007). The nutritional and bioactive components of European edible seaweeds.
[4] Bord Bia (2007). Consumer Lifestyle Trends. Bord Bia Report.

CyberColloids enlisted the help of an international flavour house to develop a unique flavour language for edible seaweeds. Subsequently, CyberColloids staff were trained in the use of this flavour language. CyberColloids now has an experienced panel of sensory analysts that is available to assess seaweed flavours and to the best of our knowledge, we are the only company in Ireland with the capacity to do so.

A range of concept products were formulated, based on (i) an assessment of market needs, (ii) available methodology and (iii) the status of Irish seaweeds as a commercial resource. Thirteen commercially available Irish seaweeds were screened for potential use in the project, based on (i) current or potential commercial availability and (ii) potential as a raw ingredient for flavour generation. Eight were selected for further assessment.

CyberColloids wished to develop processing techniques for seaweed ingredients that were more in line with those found in the kitchen than those found in large scale industrial processing facilities. Kitchen chemistry was employed to explore the effects of processing on flavour development and modification but the research had a strong scientific basis.

A range of concept products were identified, recipes were developed and screened in-house for potential. Concepts were rejected, accepted or modified, depending on the outcome of sensory assessment. Three products are currently being assessed by an Irish food company with view to commercialisation later in the year.

In every sense, this project has been highly successful, key outcomes are as follows:

- the development of an extensive new knowledge base in the area of flavour and flavour development in foodstuffs, specifically seaweeds but transferable to other foods;
- the acquisition of a new capability to assess the unique flavours of Irish seaweeds through the development and use of a flavour language for seaweeds; and
- the development of a range of concept recipes and products that are currently being assessed by an Irish food company (OHCo. Ltd., Co. Wicklow) with a view to commercialisation towards the end of 2010.

2. Project Description

As experts in hydrocolloid chemistry, CyberColloids have been working with seaweed derived food ingredients for many years. The company has a strong understanding of how hydrocolloids from seaweed, like agar, alginate and carrageenan behave in food systems and since 2005, has also been developing expertise in the nutritional aspects of edible seaweed and seaweeds as functional foods. However, experience has shown that the taste of seaweed can be an issue. Taste is still the key driver in the food industry and consumers will not compromise even for the most nutritious of foodstuffs. Despite being eaten for centuries, the unique flavours of seaweed are still not widely accepted in Ireland and Europe.

Five core areas of research were developed, each with specific objectives and deliverables as outlined below.

1. Building a knowledge base on flavour within CyberColloids

The foundation for the whole project was based on this initial phase of the work as CyberColloids needed to build an understanding of the science behind flavour development and enhancement in seaweeds. Key to this was identifying the components in seaweed that were responsible for taste and flavour and also how various cooking and simple processing techniques affected the development and modification of flavour. This work was carried out through critical review of the literature and some discussion with industry.

2. Building a capability to assess taste and flavour

Being able to critically assess different tastes and flavours was seen as a crucial part of the project. In the food industry, this is typically carried out using specially trained sensory panels. CyberColloids sought to find such a panel to assess seaweed derived products however the flavours associated with seaweed generally fall outside the range assessed by standard sensory analysis panels. When this project commenced, there were no trained panels focussing on seaweeds in either Ireland or the UK which posed a serious challenge to the research and may have caused major difficulties.

With the help of an international flavour house, CyberColloids was able to develop new flavour sensory analysis; to assess seaweed flavours and to the best of our knowledge, CyberColloids is the only company in Ireland with capacity to do so.

The flavour language was initially used to screen edible seaweeds for flavour potential and subsequently to develop flavour profiles for candidate seaweeds. Throughout the project, the flavour language was used to assess the various effects of cooking and processing on seaweed flavour. Ultimately, it was used to screen a range of concept products that contained seaweed as a flavour ingredient.

3. Formulating product concepts

One of the key aims of this project was to produce a range of products for commercialisation. A range of product concepts with commercial potential were identified, these concepts fell into one of the following categories (i) a dry condiment, (ii) a dry seaweed ingredient for savoury application, (iii) a powdered flavour base (bouillon). Formulation of concept products, from which the final products were derived, was based on (i) an assessment of market needs, (ii) available methodology and (iii) the status of Irish seaweeds as a commercial resource.

An assessment of global, European and Irish market trends was carried out along with a market needs analysis for product containing seaweeds. In addition, over 1000 patents (lodged through the European Patent Office between 1960-2008) were reviewed and a trend analysis made. A critical review of salt (sodium) and MSG (monosodium glutamate) reduction was also carried out. Formulation of products with reduced salt (sodium) and no added flavour enhancers (MSG) was identified early on in the project as an area with high potential for seaweeds.

In order to establish likely candidate seaweeds for the current project, thirteen edible seaweeds (Tab. 1) were screened. With the exception of Sugar kelp that was sourced from Iceland, all seaweeds were Irish. Screening was based on the following important criteria (i) current or potential commercial availability and (ii) potential as a raw ingredient for flavour generation.

Table 1: Edible Irish seaweed species that were assessed as potential candidate species for the current project

	Common name	Scientific name	Candidate
Brown seaweeds	Atlantic wakame	*Alaria esculenta*	Y
	Kombu	*Laminaria digitata*	Y
	Sugar kelp (from Iceland)	*Saccharina latissima*	Y
	Sea spaghetti	*Himanthalia elongata*	Y
	Channelled wrack	*Pelvetia canaliculata*	
	Spiralled wrack	*Fucus spiralis*	
	Bladder wrack	*Fucus vesiculosus*	Y
	Serrated wrack	*Fucus serratus*	
	Egg wrack	*Ascophyllum nodosum*	Y
Red seaweed	Dulse	*Palmaria palmata*	Y
	Irish Moss	*Chondrus crispus*	
	Nori	*Porphyra spp*	Y
Green seaweed	Sea lettuce	*Ulva rigida* (*Ulva lactuca* also likey)	Y

Of the thirteen seaweeds initially screened, Atlantic Wakame, Kelp, Sea spaghetti, Bladder wrack, Egg wrack, Dulse, Nori & Sea lettuce were identified as candidates for the project. However, during the course of the research it became evident that a food grade supply of Bladder wrack was difficult to secure and that Nori was in too short supply. Bladder wrack was subsequently dropped from the study and Nori was used only when available. A supply of Sugar Kelp from Iceland was secured later into the project and was included in some of the assessments.

4. Developing cooking & processing methodologies

The aim of this work was to develop techniques that were more in line with those found in the kitchen than those found in large scale industrial processing facilities but the research had a strong scientific basis. The effects of processing on flavour development and modification were assessed in terms of the chemistry taking place. Optimal reaction conditions (temperature, time, pH) were determined for various cooking processes like roasting, toasting, boiling, steaming and frying, through the development of flavour profiles for each seaweed and cooking process.

Cooking is essentially kitchen chemistry and when viewed as such, scientific explanations can be provided for all of the flavour changes taking place in a foodstuff. Processes like

caramelisation, Maillard reactions*, hydrolysis and fermentation are widely used in industry to generate flavour and all are based directly on or mimic traditional and home cooking practices. The study of kitchen chemistry is more widely known as molecular gastronomy*.

In this project, we explored the use of standard cooking methods, pickling (simple fermentation) and cooking with food grade acids like vinegar and lemon juice (hydrolysis) to generate flavour in seaweeds. We also explored the use of food grade enzymes to break down the carbohydrate and protein components of the seaweeds.

Flavour develops or is modified by cooking and processing in a number of ways (i) by physically degrading substances and releasing potential flavour compounds (ii) by bringing about chemical reactions that generate flavour and (iii) by concentrating available flavour compounds e.g. dehydration. In order to assess the first, a number of colourimetric assays were used to quantify the presence of potential flavour components like free amino acids and reducing sugars that are known to participate in important reactions like Maillard reactions and caramelisation. Seaweeds were assayed pre and post various cooking methods to assess the potential for those methods to liberate flavour compounds.

5. Designing a range of finished products with view to commercialisation

A range of concept products were identified early in the project, based on information from scientific review, technical review and market analysis. Subsequently, recipes were developed for suitable seaweed ingredients. Seaweed flavour was incorporated into products either through the addition of a seaweed ingredient that had been pre-processed in some way as to encourage flavour development or through the addition of dried seaweed that would undergo a flavour change during the preparation/cooking of the product.

Concept products were screened in-house by the trained sensory panel. Products were rejected, accepted or refined based on the opinion of the panel.
Selected products were taken to a small Irish food company with view to potential commercialisation. The company expressed an interest in taking three of the products which are currently being assessed for incorporation into the company range. It is hoped that trial sales for the first product will commence later in the year.

---

* *Maillard reactions take place between free amino acid and reducing sugar groups and are responsible for many of the flavours that develop in coffee, baked products and roasted meats for example.*

* *Recommended texts*

1. McGee, H. (2004). On Food and Cooking: the science and lore of the kitchen. Scribner, New York.
2. This, H. (2005). Molecular Gastronomy: exploring the science of flavour. Columbia University Press, New York.

3. RESULTS AND OUTCOMES

Globally, there is a current resurgence in the interest of using seaweed as a food ingredient (Tab. 2), either as a whole vegetable or in various processed forms. A number of Irish and International companies have been identified (either approached CyberColloids or targeted by CyberColloids) with an interest in incorporating seaweed ingredients (either whole or processed to some extent) into their products.

In every sense, the project has been highly successful, key outcomes have been (i) the development of an extensive new knowledge base in the area of flavour and flavour development in foodstuffs, specifically seaweeds, (ii) the acquisition of a new capability to assess the unique flavours of Irish seaweeds through the development and use of a flavour language for seaweeds and (iii) the development of a range of concept recipes and products that are currently being assessed by an Irish food company with a view to commercialisation towards the end of 2008.

Table 2: Use of edible seaweeds in commercial products worldwide

	SALTS[1]	DRY CONDIMENTS[2]	LIQUID CONDIMENTS[3]	SOUPS & SAUCES[4]	FLAVOURED MARINADES[5]	BAKED PRODUCTS[6]	PASTA[7]	SAVOURY PRODUCTS[8]	BEVERAGES[9]	SWEET PRODUCTS[10]
Egg wrack										
Sea spaghetti			✔		✔	✔		✔		
Kombu	✔	✔	✔	✔		✔		✔	✔	✔
Atlantic wakame		✔	✔		✔	✔	✔		✔	
Sugar kelp										
Dulse	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Nori	✔	✔	✔		✔	✔	✔	✔	✔	
Sea lettuce	✔	✔	✔		✔		✔		✔	

NB: Typical products in each category being (1) sea salt (2) savoury sprinkles, gomasio, dried salad dressings (3) pesto, tartare, mustard, mayonnaise, tapenade (4) soups & sauces for pasta (5) oil or brine based dressings for preserved products (6) biscuits and crackers (7) pasta and lasagne (8) sausages, cheeses, burgers, tofu products (9) teas, wine, beer (10) sweet conserves

In Ireland specifically, this interest is being driven by (i) a natural seaweed resource that is presently under exploited and huge potential exists for the development of new, innovative business that taps this resource, (ii) a national marine strategy that is promoting the sustainable exploitation of marine resources to build and revitalise the marine economy, (iii) a rapidly developing, globally respected reputation for research in the field of health and wellness/functional food products and (iv) a resurgence in the production of speciality and artisanal foods and a revitalisation of traditional Irish foods.

Despite an increased awareness of and exposure to different food cultures and ingredients, the "western" palate is still generally not accepting of many of the tastes and textures associated with Asian products derived from seaweed that are increasingly found in our markets. Consumer trend analysis in Ireland (and Europe in general) clearly shows that the taste of a food product is key and even the most health conscious and well informed consumers are unwilling to compromise.

Development of a flavour language for Irish seaweeds

This flavour language consists of a number of recognised aromas and flavours (known as descriptors) that can be used to "describe" the taste of seaweed samples. Using samples provided by CyberColloids, the flavour house sensory team were able to identify a set of key descriptors that could be applied to all of the Irish seaweeds studied during the course of this research. A number of other descriptors have subsequently been identified by CyberColloids through putting the flavour language to use, and these have been introduced into the flavour language.

A team of six people from CyberColloids were trained by a sensory analyst from the flavour house in the skills necessary to establish a sensory service for edible seaweeds. CyberColloids now has the necessary materials, protocols and trained sensory panel in place to build on this capability. Weekly training sessions have been used to embed the flavour language skills in the company and to screen Irish edible seaweeds for use in the project.

The developments of the flavour language for seaweed and subsequent training have provided CyberColloids with the capacity to assess the sensory profile of the eight edible seaweeds previously mentioned. Each seaweed has been assessed in a number of formats so as (i) to determine how cooking and processing can affect the flavour profile of the seaweed and (ii) to determine in which format the seaweed can be best used to maximise its flavour potential.

However, the overall sensory perception of seaweed as an ingredient is not only based on taste but also aroma, texture and physical appearance. Flavoursome seaweeds can still be considered unpalatable if the texture or appearance is off putting. In their dried state, some seaweeds can be difficult to render into suitable flakes or powders for use as palatable ingredients hence a range of processing techniques have been applied to physically degrade the seaweed into more applicable formats.

Assessing the flavour potential of Irish seaweeds

Generally, when seaweed is added to a recipe or product, the flavour profile changes and this change can be both positive or negative. Due to the often strong marine flavour profile of Irish seaweeds it is difficult to determine whether changes are due to a modification of the flavour profile through the addition of characters that are typical of seaweeds (e.g. marine, seaweed, salty, sulphur) or to a modification of the flavour profile through enhancement or potentiation of flavour characters typical of the food to which the seaweed has been added.

Salt (NaCl) is a recognised flavour potentiator, and there is no doubt that the "salty" taste of some seaweeds improves the flavour profile of recipes, however, protein based compounds are also present in the seaweeds and these may be responsible for enhancing some flavour characteristics (e.g. umami, meaty and roasted) and also providing textural mouthfeel.

Flavour modification

All of the seaweeds assessed in this project change the flavour profile of recipes and products in which they are added by incorporating new flavour characteristics. Some changes are deemed positive and some negative by sensory panellists.

Several seaweeds can improve the flavour profile of recipes by giving a more rounded or complete flavour sensation *e.g.* Atlantic Wakame and Dulse improve the flavour of a vegetable soup base to the extent that no extra seasoning is required. The seaweeds add saltiness but also a give the soup a more flavoursome profile and rounded taste.

Only Dulse and Irish Nori appear to have true flavour enhancement properties. Both seaweeds modify the flavour profile of test broth by significantly enhancing the flavour characteristics that are typical of the broth i.e. the vegetable and chicken meat characteristics. Both seaweeds are high in protein and it is likely that proteinaceous flavour enhancer substances, akin to MSG, are present.

Salt replacement

Salt replacement or more accurately, sodium replacement, is a key driver in the food industry today and natural sources of non-sodium "saltiness" are sought after. Seaweeds naturally contain high levels of minerals (Tab. IIA, Appendix II) , including sodium but also other key minerals such as potassium, magnesium, zinc, iron and calcium that can all add to the "saltiness" of seaweed and play a role in flavour development.

For example, 1g of table salt (NaCl) contains 0.4g of sodium whereas 1g of Irish seaweed contains between 0.025g to 0.047g sodium (Tab. 3) depending on the species and locality. Irish seaweeds also contain between 0.024g to 0.12g potassium per gram and usually have higher potassium levels than sodium (Tab. 3). Table 3 shows that between 9g and 18g of seaweed, depending on species, can be added to a recipe before sodium levels approximate the 0.4g that is found in 1g of table salt (NaCl). Often however, the aesthetics of added seaweed limits the amount that can be used as too much can be off putting.

Table 3: Sodium and potassium content of Irish seaweeds

	Na per g dry seaweed	g seaweed required to match Na content of 1g table salt	K per g dry seaweed
Egg wrack (Irish)	0.022	18	0.019
Sea spaghetti	0.041	10	0.12
Kombu	0.047	9	0.12
Atlantic wakame	0.04	10	0.09
Sugar kelp	0.025	16	0.11
Dulse (Irish)	0.025	16	0.10
Nori	n/a	n/a	n/a
Sea lettuce	0.037	11	0.024

A number of recipes have been developed that use lower than suggested, even no, added salt by replacement with ground or powdered Irish seaweed. Atlantic Wakame and Dulse in particular but also Irish Nori and Sea Lettuce, have been used to replace table salt in a range of recipes and products. One lower salt concept product that uses Atlantic Wakame to replace some of the added salt ingredient is currently being assessed by an Irish company for commercial potential.

In our recipes, seaweed is generally added at 5% to 10% based on aesthetic and flavour preferences. By replacing salt with seaweed at such levels, approximately a 1% reduction in added sodium is achieved. For example, in one product, 5g of either Atlantic Wakame or Dulse is added, this equates to 0.2g or 0.125g (respectively) of sodium. In the base recipe not

containing seaweed, 2g to 3g of salt or 0.8g to 1.2g of sodium are added. Although this reduction appears marginal, the recommended average daily intake of sodium for adults is less than 2g per day i.e. less than 5 g salt per day which is a tough target to meet given that Europeans on average consume 2 to 3 times this amount. Therefore any small reduction is beneficial.

Summary of flavour potential for Irish edible seaweeds

Based on all of the information gathered during the course of this study, the following summary for flavour potential of the eight seaweeds is given. Key points are detailed in Table 4 below.

- *Good flavour potential*

Atlantic Wakame and Dulse offer the greatest potential for flavour in either a natural or mildly processed format. Both are suitable for use as dry or wet ingredients and are suitable for use in both dry and wet food applications. Both have been successfully incorporated into a number of recipes and products.

Irish Nori has similar potential but is difficult to source, undoubtedly this seaweed would have been more widely used during this project if not for this fact.
Dulse and Irish Nori are the only two seaweeds screened here that appear to have true flavour enhancement properties but all three can be used to generally improve flavour through the addition of pleasant flavour characteristics and saltiness.

- *Some flavour potential*

Kombu also has good flavour potential but is a little more limited in its application. In a dried flake or powder format, this seaweed is tough and gritty and is difficult to incorporate into recipes and products. Although not as flavoursome as its Japanese counterpart, the flavour and texture of Irish Kombu can be improved with mild processing. Further study of the way in which Japanese Kombu is harvested, matured and processed is recommended.

Processed Sea spaghetti and Sugar Kelp have some flavour potential. Processing improves the flavour profile of these seaweeds by decreasing the typically marine characteristics that sensory panellists find off putting. Fresh Sea spaghetti is very pleasant and has great textural appeal. It tends to take on the flavours of other ingredients and hence is very versatile as a sea vegetable.

Sea lettuce also has some flavour potential. In general this seaweed is not appreciated by sensory panellists because of the over powering marine characteristics. However, in moderation or in combination with other seaweeds and in the appropriate application, Sea lettuce can be used to add saltiness and marine flavours.

- *No flavour potential*

Egg wrack is the only seaweed studied here that appears to have no flavour potential given the current assessments and mild processing techniques used. The flavour profile of Egg wrack is unpleasant, strongly marine and has a distinctive flavour and aroma that is not appreciated by sensory panellists. Processing does not improve the flavour of this seaweed.

Table 4: Summary of flavour potential for Irish seaweeds

Seaweeds	Egg wrack	Sea spaghetti	Kombu	At. wakame	Sugar kelp	Dulse	Irish nori	Sea lettuce
Sensory evaluation	**(+) indicates positive flavour profile (-) indicates negative flavour profile**							
Dry application								
•Aroma	**(-)**	**(-)**	**(+)**	**(+)**	**(-)**	**(+)**	**(+)**	**(-)**
•Taste	**(-)**	**(-)**	**(+)**	**(+)**	**(-)**	**(+)**	**(+)**	**(-)**
Wet application								
•Aroma	**(-)**	**(+)**	**(+)**	**(+)**	**(-)**	**(+)**	**(+)**	**(-)**
•Taste	**(-)**	**(+)**	**(+)**	**(+)**	**(-)**	**(+)**	**(+)**	**(-)**
Processed seaweed								
•Aroma	**(-)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(-)**
•Taste	**(-)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(-)**
Flavour potential	**(+) indicates potential (-) indicates no potential (n/a) indicates not assessed**							
Flavour modification	**(-)**	**(-)**	**(+)**	**(+)**	**n/a**	**(+)**	**(+)**	**(-)**
Salt replacement	**(-)**	**(-)**	**(-)**	**(+)**	**n/a**	**(+)**	**(+)**	**(+)**
Commercial application	**(+) indicates viable concepts developed (C) indicates commercial interest**							
Acceptable concept products				**(+)**		**(+)**		
Commercial interest				**(C)**		**(C)**		

4. Impacts and Benefits

CyberColloids has reaped a number of very real benefits from undertaking this project. At the outset of the project, the company had a position of strength in the area of hydrocolloids and was developing an expertise in seaweeds for health and nutrition. Through this project, the company has built a substantial knowledge platform and new skill base in the area of taste and the ability to analyse for taste.

From a commercial perspective, this is seen to strengthen the companies competitive advantage as follows:

- CyberColloids has the necessary expertise in taste (specifically for seaweed in savoury applications) which can be further developed and sold as an additional service;
- A transferable knowledge of taste and the ability to analyse for taste that can be applied to a range of food projects not just those related to seaweed;
- CyberColloids is in an even stronger position to offer a service in the key areas of food development i.e. texture, nutrition and taste; and
- CyberColloids has a stronger position in seaweed, specifically with regard to formulating new products suitable for commercialisation.

Three spin-off projects have already been identified in collaboration with the flavour house. Two short to medium term projects have already started, the third long term project is in developmental stage pending results of the other projects.

A range of products containing seaweed are currently under assessment with an Irish food company with view to commercialisation later in the year.

APPENDIX I: COMPANY DESCRIPTION

CyberColloids Ltd (www.cybercolloids.net) is a global contract research to business development company in the area of food texture and nutrition with a specific knowledge in hydrocolloids. The combined technical and commercial expertise and experience within the international CyberColloids team enables it to offer a unique service in translating available and emerging science, particularly in the field of polysaccharide hydrocolloids, for commercialisation by its industry clients.

CyberColloids offers a range of services globally:

- **Research and development-** from basic research, through product development, to final application testing.
- **Innovation** – the company is experienced in translating novel ideas into hydrocolloid processes and products, adding value to the concept and generating profit for the client.
- **Business development** - technical support and market introductions
- **Sales and marketing support** – the company offers a one-stop shop for hydrocolloid knowledge and an ideal route for clients without the capability to handle technical marketing.
- **Developing sourcing strategies** - offering expertise to companies on sourcing of ingredients
- **Training** - support in hydrocolloid training, both basic and in food applications
- **Manufacturing and toll manufacturing opportunities**
- **Publications and literature** – the company offers the Quarterly Technology Review and a wide range of information search services to its members.

Formed in 2002, by a group of four individuals, the company now employs 12 staff

APPENDIX II: NUTRITIONAL COMPOSITION OF EDIBLE SEAWEEDS

Tables IIA & B below outline the nutritional composition of seaweeds used in this research. Table IIA gives analysis of actual samples used in the study, Table IIB gives comparative data compiled from the literature.

Table 11A: Nutritional composition of seaweeds used in this study

Seaweeds	Irish Egg wrack	Scottish Egg wrack	Irish Sea spaghetti	Irish Kombu	Irish Atlantic wakame	Icelandic Sugar kelp	Irish Dulse	Icelandic Dulse	Irish Sea lettuce
	CC1917	**CC1616**	**CC1915**	**CC1914**	**CC1867**	**CC1926**	**CC1912**	**CC1853**	**CC1918**
harvest date	May 2009	April 2008	May 2009	May 2009	April 2009	May 2008	May 2009	May 2008	May 2009
per 100g dry weight									
Energy (k joules)	1143.00	1195.00	918.00	950.00	1012.00	1173.00	803.00	1285.00	1191.00
Energy (k calories)	270.00	282.00	217.00	224.00	238.00	276.00	189.00	303.00	281.00
Total protein (g)	6.10	5.40	12.50	10.10	11.00	7.30	11.30	16.60	21.80
Total carbohydrate (g)	54.80	57.90	37.80	43.80	46.80	59.50	34.00	57.90	43.70
Total fat (g)	2.90	3.20	1.70	0.90	0.80	1.00	0.90	0.50	2.10
saturates (g)	0.55	0.60	0.45	0.21	0.26	0.34	0.36	0.25	0.59
monosaturates (g)	1.30	1.60	0.43	0.30	0.24	0.31	0.11	<0.10	0.70
polyunsaturates (g)	0.90	0.88	0.74	0.34	0.26	0.31	0.37	0.16	0.69
trans fatty acids (g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Moisture (g)	17.60	11.60	13.00	15.50	15.20	11.60	27.60	7.60	16.70
Ash (g)	18.62	21.93	34.97	29.75	26.19	20.63	26.20	17.39	24.69
Calcium (g)	0.83	1.50	0.92	1.10	1.00	1.00	0.16	1.20	0.38
Iron (g)	0.02	0.07	0.02	0.02	0.04	0.02	0.01	0.07	0.06
Magnesium (g)	0.61	0.64	0.81	0.88	0.79	0.60	0.30	0.15	1.50
Potassium (g)	1.90	3.10	12.00	12.00	9.00	11.00	10.00	4.40	2.40
Sodium (g)	2.20	2.70	4.10	4.70	4.00	2.50	2.50	0.50	3.70
Zinc (mg/kg)	27	40	22	26	52	22	26	28	1

Table 11B: Key nutritional components of edible seaweeds based on previously reported data *

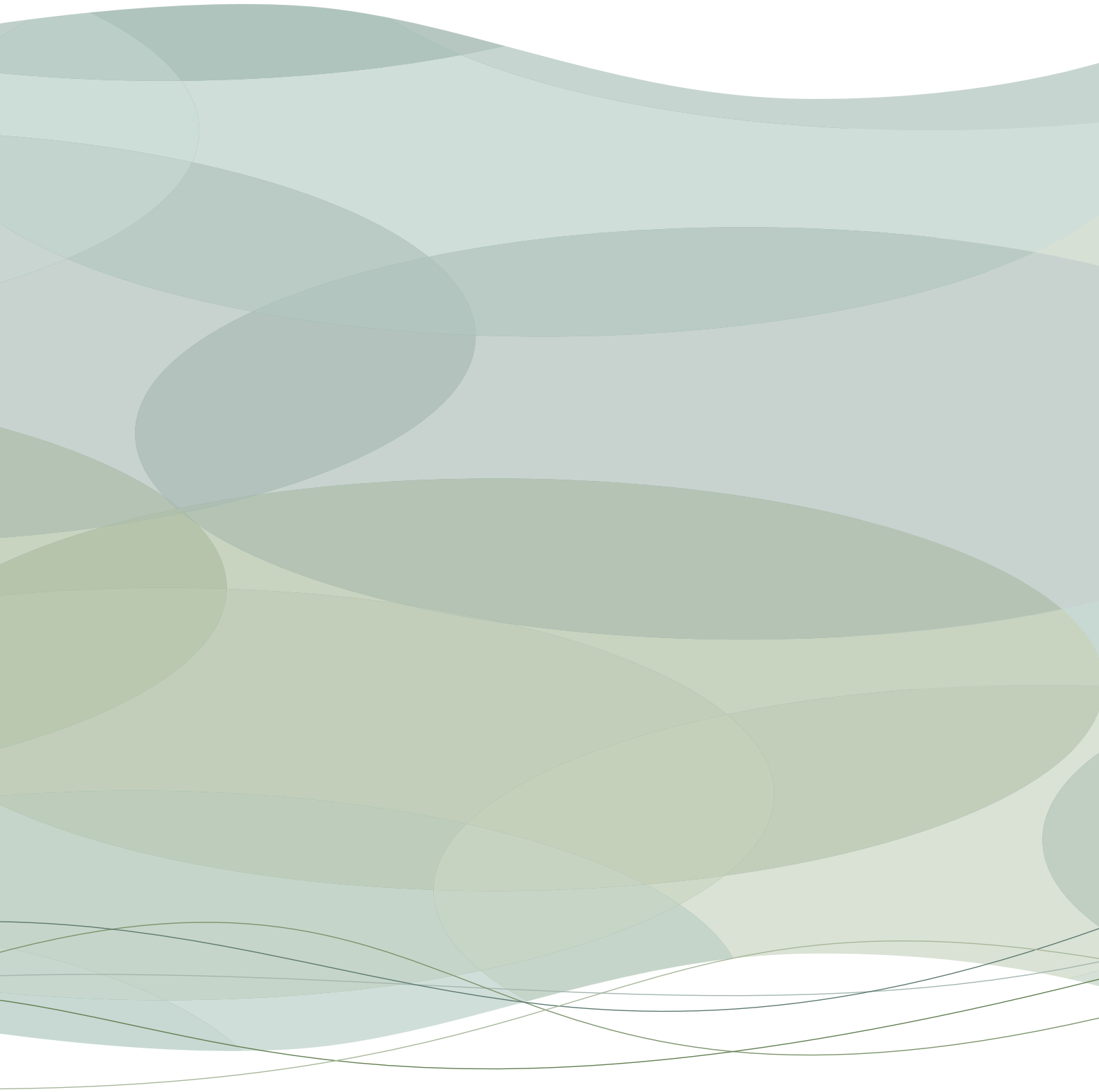
	% of nutritional components			
	Protein	**Lipid**	**Carbohydrate**	**Minerals**
Egg wrack	5-12	2-4	42-64	14.5-23.8
Sea spaghetti	6-11	0.5	61	20-30
Kombu	8-14	1	48	17.3-36.2
Atlantic wakame	9-20	1-2	46-51	
Sugar kelp	6.4-14.6	0.7	59.4	16.7-41
Dulse	12-21	0.7-3	46-50	11.7-32.5
Nori	15-37	0.12-2.48	50-76	15-35
Sea lettuce	15-25	0.6-1	42-48	13.7

* Data from:-

1. Morrissey, J., Kraan, S. & Guiry, M.D. (2001). A Guide to Commercially Important Seaweeds on the Irish Coast. pp. 66. Dun Laoghaire: Bord Iascaigh Mhara.

2. Institut de Phytonutrition. Functional health and therapeutic effects of algae and seaweed. Electronic database Version 1.5. Bolsoleil, France 2004.

Produced by the Sea Change Management Unit, Strategic Planning and Development Services, Marine Institute



www.marine.ie

Headquarters
Marine Institute
Rinville
Oranmore
Co. Galway
Tel: +353 91 730 400
Fax: +353 91 730 470
Email: institute.mail@marine.ie

Marine Institute Regional Offices & Labratories

Marine Institute
80 Harcourt Street
Dublin 2
Tel: +353 1 476 6500
Fax: +353 1 478 4988

Marine Institute
Furnace
Newport
Co. Mayo
Tel: +353 98 42300
Fax: +353 98 42340