2015-4

An Investigative Study Into the Beneficial Use of Seaweed in Bread and the Broader Food Industry.

James A. Griffin
Technological University Dublin, james.griffin@dit.ie

An investigative study into the beneficial use of seaweed in bread and the broader food industry.

A dissertation presented to Dublin Institute of Technology, School of Culinary Arts and Food Technology in partial fulfilment of the requirements for the Bachelor's Degree BSc (Hons) Baking & Pastry Arts Management.

By
James A. Griffin
April 2015

Supervisor Dr. F. Cullen

Declaration

I certify that this dissertation, which I now submit for examination for the award of Bachelor's Degree (Hons) in Baking & Pastry Arts Management, is entirely my own work, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within my work.

This dissertation was prepared according to the regulations of Dublin Institute of Technology and has not been submitted in whole or in part for an award in any other institute or university.

The Institute has permission to keep, to lend or to copy this dissertation in whole or in part, on condition that any such use of the material of the thesis is duly acknowledged.

Signed: _____ Date _____

James A. Griffin

Abstract

The primary objective of this research was to investigate the beneficial use of seaweed in bread and the broader food industry. The author began the thesis by reviewing Japan's consumption of seaweed (the highest, per capita, in the world, with the lowest incidence of obesity and cancer). The author introduced a new Irish seaweed product and examined how seaweed could be integrated more effectively into the Western diet. Using the literature reviewed in Chapter Two, the author explored the nutritional aspects of how seaweed is used both in Asian cuisine and in Western culture, in addition to how seaweed use could be promoted and improved in the West. Health is of major interest in society today, with health and nutrition being very strongly interlinked. The research indicated that, not only was seaweed nutritious, but it was also good for health. The expression "you are what you eat" has become a way of life for many consumers, who choose healthy options over highly processed alternatives.

The Western diet and food culture differs greatly from that of Asia, and so different approaches are required to encourage greater consumption of seaweed. Bread and baked products are consumed by most Western countries. Adding dried seaweed to flour for baked goods, or in health drinks, were considered the most appropriate models for achieving this, and indeed yielded encouraging results. In Chapters Three and Four, the author set out the methods and analysed the results collected from both an online survey and the sale of seaweed baked goods over a six-month period. The responses from both the survey and actual sales were encouraging, and most respondents were interested in eating seaweed breads. In conclusion, it is interesting to speculate as to what the health benefits for various populations would be if merely a small percentage of dried seaweed were added to the breads, pastas, wraps, tortillas and pita and breads of the world.

Acknowledgements

There are many people I wish to thank for their support along this journey in committing to, writing and researching this thesis. I would like to begin by thanking, most sincerely, Dr. Frank Cullen for giving me the opportunity to complete my honours degree. The devotion of his time, patience and dedication to me in his capacity as my supervisor was second to none. Thank you.

I would also like to thank all the staff of the DIT, Cathal Brugha Street campus, for making me feel so welcome and so at home, and for always treating me like a team member, through their continued support and encouragement.

I wish to thank the hard-working staff at Griffin's Bakery, who, through their dedication and commitment to Griffin's, have taken the burden of work from me and enabled me to complete my degree without the worry of business matters.

Finally, to my wonderful family, my children, Dillon, Janice and Sophie, who inspire me daily; but, most of all, to my devoted and beloved wife Bogna, for her daily commitment, support, dedication and love. She has taught me that dreams do come true; it is just a matter of believing in them, and in yourself. Without her support, none of this would have been possible to achieve.

Table of Contents

Declaration i

Abstract ii

Acknowledgements iii

List of Figures, Tables, Graphs and Recipes vii

List of Abbreviations x

Chapter One: Introduction and Contextual Overview 1

1.1 Introduction 1

1.2 Contextual overview 1

1.3 Aims and objectives 2

1.4 Structure of the dissertation 3

Chapter Two: Literature Review 5

2.1 Introduction 5

2.2 A brief history of seaweed use in food 5

2.3 Main types and uses of seaweeds in food 6

2.4 The use of seaweed in food, bread and beverages 9

2.5 Exploring the health aspects of seaweed use in foods 10

2.6 The introduction of seaweed trials using baked goods and alginate drinks 11

2.7 Examining methods of introducing seaweeds into the national diet 13

2.8 The delivery of nutrients to the population using flour or bread 15

2.9 The health benefits of seaweed consumption 15

2.10 Gastronomic and food-preservation properties of seaweed 17

2.11 Scientific findings concerning the benefits of the use of seaweed in bread 17

2.12 The seaweed market in Ireland, and its global potential 19

2.13 Harnessing the national and export potential of Irish seaweed 20

2.14 Potential hazards concerning the use of seaweed in food 21

2.15 Chapter conclusion 23
Chapter Three: Methods and Methodology 25
3.1 Introduction 25
3.2 Research topic and design 25
3.3 Sources of data 26
3.4 Quantitative research 26
3.5 Qualitative research 27
3.6 Case study 27
3.7 Data collection 28
3.8 The reliability and validity of survey data 29
3.9 Ethical considerations 29
3.10 Limitations 30
3.11 Chapter conclusion 31
Chapter Four: Results and Discussions 32
4.1 Introduction 32
4.2 Commercial use of NORI Bake Pro in Irish bakery products 33
4.3 Dough appearance, and applications using dried seaweed 35
4.4 Online survey using the collection tool SurveyMonkey 35
4.5 Demographic information 36
4.6 Summary, whether coastal dwelling respondents were influenced by seaweed foods 37
4.7 Summary, whether respondents consume nutritional supplements 37
4.8 Summary, nutritional product choices that influence purchasing decisions 38
4.9 Summary, frequency with which respondents included a daily healthy food option... 39
4.10 Summary, importance of a healthy diet combined with exercise 39
4.11 Summary, whether respondents had ever consumed a seaweed product 40
4.12 Summary, prior knowledge of health benefits from seaweed consumption 41
4.13 Summary, seaweed bread makes one feel fuller for longer 42

4.14 Summary, seaweed bread combined with exercise can lead to weight loss 43
4.15 Summary, perceptions of a seaweed baguette's appearance 44
4.16 Summary, reactions to seaweed Danish pastry images 45
4.17 Summary, seaweed soda bread images 46
4.18 Summary, reactions to seaweed flapjack images 47
4.19 Summary, perceptions of seahorse baguette images 48
4.20 Summary, seaweed goods liked the most 49
4.21 Summary, using seaweed in foodstuffs and baked goods 50
4.22 Summary, seaweed-baked goods in the future 51
4.23 Summary, top two important factors when purchasing baked goods 52
4.24 Summary, whether respondents would purchase a seaweed-baked product 53
4.25 Summary, weekly expenditure on bakery products 54
4.26 Summary, age profile 56
4.27 The main findings from the primary research 57
4.28 Chapter conclusion 58
Chapter Five: Discussion 60
5.1 Introduction 60
5.2 Aims and objectives 60
5.3 Key findings 61
5.4 Conclusion 63
5.5 Limitations 64
5.6 A final word 65
Works Cited 66
Appendix A – SurveyMonkey response count and response percentages 79
Appendix B – Questionnaire 90
Appendix C – Seaweeds for human consumption 98
Appendix D – Bord Bia Bakery Market Surveys 2014 102

Appendix E – Sample clinical trials of seaweed in bread and beverages 105
Appendix F – NORI Bake Pro product background 112
Appendix G– Test baking trials using NORI Bake Pro 116
Appendix H – Seaweed product recipes and production methods 122
Appendix I – Questionnaire cover page 130

List of Figures, Tables, Graphs and Recipes

Figure 1: The uses of seaweed 7
Figure 2: Cereal fortification by quantity per global region during 2004 and 2007 13
Figure 3: NORI Bake seaweed bread additive 33
Figure 4: SMRT Bar 33
Figure 5: Commercial application of seaweed in bread (2015) 34
Figure 6: Hydration levels breads: control compared to NORI Bake Pro recipe 34
Figure 7: Summary, to images of seaweed baguette 45
Figure 8: Summary, images of Danish pastries made with seaweed 46
Figure 9: Summary, soda bread made with seaweed 47
Figure 10: Summary, flapjacks made with seaweed 48
Figure 11: Summary, seahorse baguettes made with seaweed 49
Figure 12: Bread and morning goods consumption habits Ireland and UK 2014 104
Figure 13: Dough using 3% dry seaweed 118
Figure 14: Seahorse seaweed bread 118
Figure 15: Raw pastry with seaweed 119
Figure 16: Baked pastries with seaweed 119
Figure 17: Seaweed baguette 119
Figure 18: Seaweed flapjack 120
Figure 19: Seaweed soda bread 120
Figure 20: Seaweed sourdough bread 120

Table 1: UNICEF Flour Fortification Initiative..... 14
Table 2: Why consumers should consume seaweed..... 23
Table 3: Previous knowledge of the beneficial advantages of consuming seaweed..... 41
Table 4: Consumption of seaweed benefits known to respondents..... 42
Table 5: Summary, the average weekly spend on bakery products..... 55
Table 6: Summary, age segmentation %..... 56
Table 7: Major nutrients found in algae commonly used for human consumption..... 99
Table 8: What factors consumers consider when purchasing bread..... 103
Table 9: New bread product/type trial choices..... 103
Table 10: Nutritional data for NORI Bake Pro..... 113
Table 11: Key Nutritionals for NORI Bake Pro, per 100g..... 114
Table 12: Monthly unit sales of seaweed products in GBG..... 121

Graph 1: Summary, nationalities..... 36
Graph 2: Summary, where respondents' reside..... 36
Graph 3: Summary, respondents' purchasing nutritional products..... 38
Graph 4: Summary, Frequency of daily healthy food choices..... 39
Graph 5: Summary, importance of healthy diet combined with exercise..... 40
Graph 6: Summary, seaweed bread makes one feel fuller for longer..... 43
Graph 7: Summary, seaweed bread combined with exercise can bring about weight loss..... 44
Graph 8: Summary, most preferred products..... 50
Graph 9: Summary, concept of using seaweed in food and baked goods..... 51
Graph 10: Summary, future interest in baked goods containing seaweed..... 52
Graph 11: Summary, considerations when purchasing food or bakery product..... 53
Graph 12: Summary, respondents' attitudes to purchasing nutritional seaweed products..... 54
Graph 13: Summary, weekly spend..... 55
Graph 14: Bar chart age profile..... 57
Graph 15: Seaweed product sales at Griffin's Bakery..... 121

Recipe 1: Initial test bake recipe for James Cunningham 123
Recipe 2: Seaweed baguette 124
Recipe 3: Seaweed sourdough 125
Recipe 4: Seaweed brown soda bread 126
Recipe 5: Seaweed Danish pastry 127
Recipe 6: Seaweed flapjack 128

List of Abbreviations

BIM	Bord Iasciagh Mhara
CSO	Central Statistics Office
EPOS	Electronic Point Of Sale System
DW	Dry Weight
DHA	docosahexaeonic acid
DIT	Dublin Institute of Technology
EPA	eicosapentaeonic acid
FHIS	Food and Health Innovation Service
FMI	Food Marketing Institute
PUFA	polyunsaturated fatty acid
RDA	recommended daily allowance
RDI	recommended daily intake
UNICEF	United Nations International Children's Fund
USP	unique selling point
WHO	World Health Organization

Chapter One: Introduction and Contextual Overview

1.1 Introduction

Japan, which today has the world's largest seaweed consumption per capita, with 10-15% of the Japanese diet consisting of algae, is also associated with a significantly lower rate of cancer, thyroid diseases, heart disease and dementia than Western cultures (Fitzgerald et al. 2011; Venugopal 2011, cited in Food and Health Innovation Service 2013, p.1). Connemara Ventures Ltd., a seaweed harvesting and processing company based in the Inagh Valley in County Galway, has identified that Irish people do not consume enough seaweed. It has developed a blend of dried seaweeds for use in the baking, restaurant and snacking sector in Ireland. Director James Cunningham (CEO) and Scientific Director Dr. Stefan Kraan, a prominent seaweed scientist in the Galway Mayo Institute of Technology, have provided the researcher with working samples, nutritional information and specifications regarding the product that is presently called NORI Bake Pro. In this context, seaweed use in food goes beyond matters of flavour and nutrition, but also encompasses – by its addition to foodstuffs – how it may be used to control obesity and heart disease, and to deliver iodine into the food chain. By comparing and contrasting the most up-to-date reference material, including *Sea Plants* (Collén 2014), in addition to published scientific research, the researcher will explore the use of seaweed in food products, with a particular focus on its use in baked goods within Ireland.

1.2 Contextual overview

Awareness among the populations in the developed world, and, more specifically, Ireland, regarding health and longevity has led to fundamental changes in peoples' attitudes to such activities as dieting, regular exercise, smoking and the drinking of alcohol. According to International Living Magazine,

> optimism and purpose, a low stress level, a natural diet and an active lifestyle, experts say those factors are three times as important as your genetic makeup when it comes to enjoying a long and healthy life (International Living Magazine 2014).

The available choice of various foods and supplements to fulfil these consumer demands is growing continually. Adams (2007, p.205) expresses his concerns over highly processed foods, where the "long-term effects of additives to food are now being questioned, particularly for children, for example, the effect of certain additives on children's behaviour". There is a growing demand for organic and non-processed food choices, according to the Food Marketing Institute (FMI) (2008, p.3). The FMI explains that "certain health benefits motivate shoppers to buy natural or organic foods. For instance, people allergic to foods, chemicals or preservatives can gain relief by switching to organic foods". The horsemeat scandal (involving the inclusion of horsemeat in products advertised as beef-based, such as hamburgers) has highlighted to the greater worldwide population that processed foods may not be what they seem (Telegraph 2013). With obesity on the rise amongst young people, it is now commonplace to see children's education programmes stress the benefits of healthy living and eating (McConnell et al., 2014), which contribute to maintaining a healthy lifestyle. In the USA, Surgeon General Dr. Carmona (American Heart Association 2014) has predicted that the current generation will contain the first children to have a lower life expectancy than that of their parents. The reduction in longevity is directly attributed to obesity, according to a recent publication of The American Heart Association (2014).

Governmental and international interests influence consumer demand and the delivery of various supplements to populations, both privately and through documented national policies aimed at preserving and maintaining national health. For example, the fluoridation of state water schemes, the iodisation of salt and the legislated fortification of flour at the milling stage with calcium and folic acid are examples of tools that various governments use to provide supplements directly to the majority of their citizens (WHO 2009).

1.3 Aims and objectives

The purpose of the study is to investigate the use of, and the benefits of, seaweed in food. The literature review conducted by the author has complemented his choice of objectives, investigating the potential health role of the use of seaweed in food and bread products in Ireland. In considering the consumption habits of seaweed in foods, the research will

concentrate on the existing use of seaweed in foods. The objectives are explicitly set out as follows:

- To discuss the evolution, use and consumption of seaweed in food, with a particular focus on baked products.
- To compare and contrast literature related to the use of seaweed as a source of food.
- To investigate the health benefits of the daily consumption and general use of seaweed in foodstuffs.
- To offer recommendations concerning how to increase the use of seaweed in food products.

1.4 Structure of the dissertation

Chapter One

Chapter One sets out the main aims and objectives of the research. The work is introduced, and the theoretical framework is outlined. A brief introduction is provided which considers both the historical use of seaweed in food and examples of how seaweed is being used in food within today's evolving marketplace.

Chapter Two

In Chapter Two, the theoretical framework which underpins and informs the structure of this dissertation is developed and expanded. The works of Allen (2004), Brownlee (2010), Collén (2014), Guiry (2014), Indergaard (1983), Jensen (2011), Steele (2013), Watson (2011), Rose (2012) along with findings from the Marine Institute (2006), An Bord Iscaigh Mhara (2001) and the World Health Organization (2009), are all used to guide the research and progress the knowledge to a deeper understanding of seaweed use in food. The researcher will also explore how the regular consumption of seaweed can be achieved in food. Trials using bread and drinks which have been subject to the addition of alginates for clinical trials are explored and compared. The secondary research in Chapter Two provides an understanding of the consumption of seaweed in food and the approach by which seaweed may be distributed as part of a national diet plan. Baked goods offer high potential as a delivery vehicle for bioactive ingredients, as they are the most widely consumed goods in the world (Culliney 2014). There are many potential health benefits to be gained from regular seaweed

consumption, ranging from the intake of minerals and vitamins to iodine (Fitzgerald et al. 2014, pp.398-405). There are also risks involved in the consumption of seaweed, which can include exceeding the RDI of iodine. This is of particular interest to breastfeeding and pregnant women, and there is also a risk of the seaweed being contaminated by radiation or high levels of arsenic (FSAI 2010).

Chapter Three

Chapter Three incorporates a restatement of the aims and objectives of the study. In this chapter, the methods and methodologies available for collecting the primary data are discussed. The methods most suited to this particular study are stated, and the reasons for choosing these methods over others are explained. The data was collected over a period of two weeks, using SurveyMonkey as the online research tool. The survey focused on the respondents' perceptions of consuming seaweed through food, as a healthy nutritional supplement, with an emphasis on its use in bakery products.

Chapter Four

In Chapter Four, the data presented in Chapter Three is discussed. The various methods used are described and explained. Chapter Four establishes why the study is weighted towards the quantitative approach, rather than the qualitative approach. There is also an explanation of why the case study or interview processes were not selected for this particular study, and why new product development was used to compliment the survey. Finally, the ethical considerations involved in conducting this study are examined, in addition to how these principles are upheld, both in formatting the questionnaire and in concluding the examination of the data.

Chapter Five

Chapter Five concludes the discussion of the various questions and answers that were explored in the study. In this chapter, connections between the literature, the methodology and the findings are determined. The research question is re-examined, identifying how the objectives were achieved. The key findings are listed and referenced back to the relevant chapter. The limitations of the study are also discussed.

Chapter Two: Literature Review

2.1 Introduction

This study will focus on the historical and existing health benefits of seaweed consumption in the human diet. The findings will enable the identification, from the research, of particular types of seaweed application in food which may appeal to the health market. The research will also further examine how these products may be incorporated as part of a regular diet. Dr. Susan Steele, CEO of the Sea Fisheries Protection Authority of Ireland, is quoted below in the foreword of Sally Mc Kenna's book *Extreme Greens* (Mc Kenna 2013).

> Imagine being offered a plentiful free food. Imagine, if this free food was packed with the health-promoting minerals, nutrients and anti-oxidants, which could help you live longer and fight disease, help you lose weight and give healthy skin and hair. Imagine a natural, sustainable free food which is also proven to confer health benefits on your pets, livestock, and chickens. A free food that will make the vegetables in your garden germinate faster and be more resistant and give better yields (Steele 2013, p.7).

Edible seaweeds have historically been consumed by coastal populations across the globe. Today, seaweed is still part of the habitual diet in many Asian countries (Brownlee, et al., 2012). As residents of an island, the Irish are surrounded by the rich natural resources of the sea. There is a vastly under-utilised food resource available in the form of sea vegetables (Seaweed.ie 2015). Allen (Allen and Hatfield 2004, p 1021) have documented that, for centuries, seaweed was collected as a form of food and medicine in most coastal areas of the world. These areas include Ireland, the UK, China, Japan and south-east Asia, among many others (Allen 2004, p.1021). In addition, "A poem, probably dating from the twelfth century, describes monks harvesting dillisk (*Palmaria palmata*) from the rocks and distributing it to the poor as one of their daily duties" (Kraan 2010).

2.2 A brief history of seaweed use in food

"Brown seaweed has been an important part of the Japanese diet for centuries; it is used in soups, as an additive to change the taste of other foods and as a wrap for the raw fish and rice

combinations known as sushi" (What when how 2010). Furthermore, Indergaard (1983, pp.137-167) states that seaweed has been eaten since prehistoric times as part of a staple human diet in most Asian countries. According to Indergaard, cited in Guiry (Guiry 2015a), a Chinese scholar called Sze Teu wrote in 600 BC that "Some algae are a delicacy fit for the most honoured guests, even for the King himself". Indergaard (1983) explains that 21 species of seaweeds are used in everyday cookery in Japan today, six of which have been used since the 8th century. Kombu, wakame, nori and, in particular, kaiso seaweed, accounted for more than 10% of the Japanese seaweed diet until relatively recently. Seaweed consumption reached an average of 3.5 kg per household in 1973, in Japan, representing a 20% increase over 10 years (Indergaard 1983, pp.137-167). In Ireland, it is assumed that, at most, merely three to six tonnes of domestically produced seaweed food products are consumed annually (Walsh and Watson 2010).

Stein and Borden (1984), cited in Seaweed.ie (2015), refer to regulations for the harvesting of *Palmaria palmata* (dulse, dillisk), a red seaweed, which is mentioned in the 10th century Icelandic sagas. Laver (*Porphyra*) has been eaten in Wales since at least AD 1600 (Allen and Hatfield 2004, p.1021). It is still eaten today and produced commercially for sale in Wales, for local and export trade. The consumption of edible seaweed has also been documented in Ireland for a very long time (Bliss 1985, pp.141-166; Guiry 2015a). In Collén et.al. (2004), Bliss (1985) articulates that the domestic use of Irish moss was documented at least as early as 1809. Mitchell and Guiry support this by observing, in Collén (2014, p.57) that, in 1829, the name "*Chondrus Crispus*" (for Irish moss) alluded to its putative therapeutic properties. Furthermore, it was acclaimed for wellbeing as a remedy in Ireland at this time (Allen 2004). Collén (2014) indicates that a traditional treatment in Ireland for chest and lung ailments involved Irish moss, which was boiled in milk or water. "Various red algae have also been used in the Mediterranean as sources of dyeing agents and as anthelmintic and other health remedies since pre-Christian times" (Stein and Borden 1983, pp.485-501). While seaweed has had many uses in the past, the study will examine the main types and modern uses of seaweed in the next section.

2.3 Main types and uses of seaweeds in food

Three main uses for seaweed have been identified as follows:

- Human consumption and agriculture
- Cattle feed
- Soil enrichment.

Archaeologists and ethnologists have mentioned other uses, such as those related to fuel and filling for bedding mattresses (Netalgae.eu 2012). Parson Pickles, a food processing company based in Wales, commercially produces and sells seaweed bread mixes, and a range of other food products. Its laver bread product is described on its website as follows:

> Laver Bread is a Celtic delicacy which is produced from a particular type of seaweed. It is very similar to the seaweed which is used by the Japanese called nori. The seaweed is mainly found on the West Coast of the British Isles and Southern Ireland. After being gathered the seaweed is thoroughly washed and is cooked until it becomes soft. It is then minced to convert it into a paste like texture. Laver is nutritious, very low in calories and is rich in protein. It also contains iodine and vitamins A, B, B2, C and D. Because of the nature of the product it is classified as being able to use the vegetarian symbol (Pickles 2014).

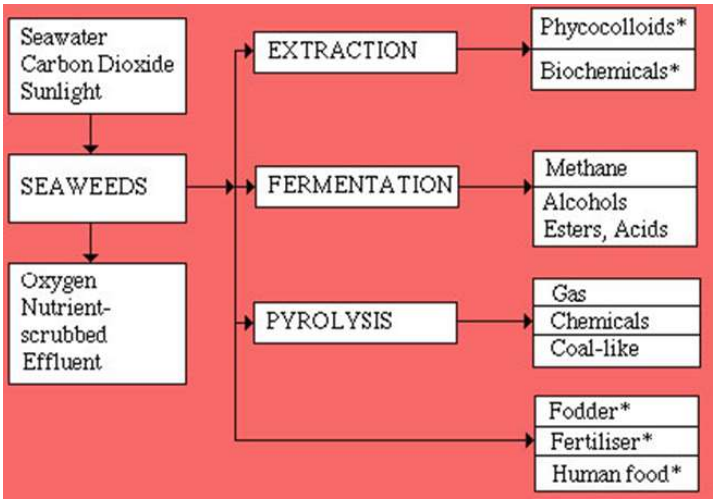


Figure 1: The uses of seaweed

Source: Seaweed.ie (2015)

Seaweed.ie (2015), a website dedicated to Irish seaweeds, explains that "the trend today is to refer to marine algae used in food as sea-vegetables". This view is supported by Myslabodski in (Fisheries and Aquaculture Department, 2003) (refer to Section 5.6). The word "seaweed"

in the English language portrays a negative image towards what is a highly regarded and nutritious foodstuff in Asia. In recent years, there has been a strong movement in France to introduce seaweed into European cuisine, with some success, although it is still regarded as an exotic component of the menu (Fisheries and Aquaculture Department 2003).

> The main species used in Ireland at present are dulse, carrageen moss, and various kelps and wracks. Dulse – also known as dillisk – is a red alga (Palmaria palmata). It is eaten on both sides of the North Atlantic, but dulse is mostly eaten only in Ireland after it has been dried; it is frequently sold in small packets, most commonly in the west and north. It is also eaten in Canada, Iceland, Norway, France and Scotland (Seaweed.ie 2015).

Carrageen moss, or Irish moss (*Chondrus crispus* and *Mastocarpus stellatus*), is widely sold in its dried form. It is used for cooking, and also as a remedy for colds and influenza (Guiry 2015). "While dulse and carrageen moss are worthy sea vegetables with a history of utilisation and a small but proven market, other species also show considerable promise. Our kelp resources are considerably under-utilised. All of the Irish kelp species are edible, but *Saccharina latissima* (formerly known as *Laminaria saccharina*) is perhaps the most palatable, as it has a slightly sweet taste, due to high levels of mannitol. Two other brown algae generally accepted as offering potential as food are *Himanthalia elongata*, also known as thongweed, or *Ríseach* in Irish, and *Alaria esculenta*, also known as dabberlocks or murlins. *Himanthalia elongata* ("Spaghetti de mer") is widely eaten in France, after drying or pickling, and plants are also sold in Ireland in a dried form. After soaking the Spaghetti de mer in water, it is blended along with other vegetables in mixed salad; it does not have the strong seaweed taste that many find overpowering", states Guiry (2015d) in *Use of seaweed as food in Ireland*.

Sea vegetables are as nutritionally valuable as any land-vegetable, and, in most cases, they are far superior in their vitamin, trace element and even protein content. Food tastes in Europe are witnessing growth in the consumption of seaweed. This growth is set to continue to rise over the next 20 years (Seaweed.ie 2015). There is renewed interest, in Western Europe and the USA, in the use of seaweed in food applications such as cooking and baking. Authors such as Gusman (Gusman 2003), Bird (Bird 2013) and Mc Kenna (Mc Kenna 2013) support and encourage the use of seaweeds or sea vegetables in foods as a nutritional addition to food. In Asian countries, seaweed is viewed as merely another vegetable, and is used

extensively. Japanese and Korean broths made using dried fish and seaweed are considered to be the most pure umami flavour. “Seaweed is a source of a series of minerals that help contribute to a stock’s backbone and umami”, according to DiCamillio (2014). Traditionally, seaweed has been used in Japanese dashi, a stock made from the kombu variety of kelp and dried bonito flakes. According to *The Huffington Post*, the serving sizes of seaweed are often not large enough to provide a significant boost in nutrients, but they can serve as an extraordinary source of iodine (DiCamillo 2014).

Edible seaweeds commonly used for human consumption are classified into four main groups:

- Brown algae
- Red algae
- Green algae
- Macro algae

A comprehensive list of these algae can be found in Appendix C). The next section will examine the use of seaweed in food, bread and beverages. Bread application, in particular, will be researched, as “Bread is the world’s most widely eaten food and has been part of our diet since the early times of mankind” (University of Illinois 2000). It is the ideal conduit to carry alginates into the diet.

2.4 The use of seaweed in food, bread and beverages

Bread has been described as the staff of life in the Bible (Leviticus n. d.). It has been a part of human experience for thousands of years, and has been extensively documented since ancient Egyptian times, over 5,000 years ago (Food Timeline.Org 2015). While the processes and ingredients have changed down through the ages, bread is still eaten by most of the world’s population, and is viewed as a healthy food (Culliney 2014). The idea that eating the correct balance of foods might provide therapeutic benefits is undoubtedly not a new perception. The view “Let food be thy medicine and medicine be thy food” was embraced over 2,500 years

ago by Hippocrates, in 460 BC (Hopkins Medicine 2010). Japan is possibly the most notable example of a known culture with a seaweed-consuming population and history.

> Japan, which, today has the world's largest seaweed consumption per capita, with 10-15% of the Japanese diet consisting of algae, is also associated with a significantly lower rate of cancer, thyroid diseases, heart disease and dementia than western cultures.(Fitzgerald et al. 2011; Venugopal 2011, cited in Food and Health Innovation Service 2013, p.1).

In Western cultures, the addition of seaweed to bread for health reasons is, however, a relatively new concept; trials have been conducted adding seaweed to both brown and white breads since 2010 by Brownlee (Brownlee 2010) in the UK. In Denmark, Jensen (Jensen 2011) conducted trials by adding alginates to beverages and yogurts. Improving dietary habits is a societal, not merely an individual, problem. Therefore, it demands a population-based, multi-sectorial, multi-disciplinary and culturally relevant approach (WHO 2010). With the ever-increasing consumption of processed foods and a demand for more natural alternatives in food, processed foods and the additives contained therein (including plants, crops and grains which are high in natural fibre) are being promoted by the World Health Organization as essential for providing a balanced, healthy diet. Poots (2012, cited in Northern Ireland Executive 2012) states, "people should be aware of the importance of a healthy diet and taking more exercise. We must act now to avoid a future where our children face significant health problems. Individuals can make choices in everyday life that will improve and protect their health" (Northern Ireland Executive 2012). With health and diet highlighted as being of major importance in modern life (Northern Ireland Executive 2012) by government ministers such as Poots (2012), the next section will explore the health aspects of seaweed use in food.

2.5 Exploring the health aspects of seaweed use in foods

According to Rosenfeld (2000), "Early Chinese medical writings in approximately 3600 B.C. were the first to record the decreases in goitre size upon ingestion of seaweed and burnt sea sponge. Although iodine was yet to be discovered, these remedies remained effective and their use continued globally" (Rosenfeld 2000). Other medicinal uses of seaweed are noted, including carrageen moss, in *Seaweed uses and utilization* (Guiry, 2015c). Carrageenans have been patented as anti-viral agents, while corallina is being used in bone-replacement therapy

(Stein and Borden 1984). Exciting research findings by Brownlee (2010) and, more recently, Jensen (2011), involving clinical trials using seaweed in bread by Dr. Ian Brownlee in the UK and alginates in yogurts and beverages by Dr. Morgen Jensen in Denmark, are yielding promising results. Using seaweeds in breads may potentially help to control obesity and heart disease. A recent study into the use of red seaweed in bread has indicated promising results for heart health (Culliney 2014). The study, which was published in the *Journal of Food Science and Technology*, brought together researchers from Ireland and the UK. The aim of their study was to examine whether the rennin inhibitory properties in the seaweed were damaged or were effective following the baking process. The bread was tasted by a sensory panel, and found to be acceptable. The baked samples also retained their bioactivity after baking (Fitzgerald, et al., 2014). In 2012, Dr. Craig Rose was also engaged in clinical trials involving 80 obese men at Sheffield Hallam University using dried seaweed in bread (Telegraph 2012). Furthermore, Dr. Combert, a nutritionist from the School of Medicine in Glasgow, has led a study involving Scottish seaweed to treat iodine deficiency in women. The seaweed was used to replace salt which had been fortified with iodine. Her findings suggest that seaweed releases lower levels of iodine in food than salt but sustains this release over a longer period (Combet, et al. 2014). Other positive health aspects of alginate use in food include satiety, reduced plasma cholesterol, and reduced glycaemic and insulinaemic response, as discussed by Brownlee et al. (2009), cited in Rehm (Rehm 2009). There is much ongoing research in regard to the use of seaweeds in food and beverages, as discussed above. Research laboratory trials, along with clinical trials, have been conducted by Brownlee (2010) and Pelkman et al. (2007, cited in Rehm and Jensen 2011). While much research into the benefits of seaweed consumption has been documented, many of the reported medicinal effects of marine algae have not yet been substantiated, according to Guiry (2015b) in *Medicinal uses of seaweed*. The merit of these trials will be compared and discussed in the next section.

2.6 The introduction of seaweed trials using baked goods and alginate drinks

A recent study completed by the World Health Organization found that obesity, globally, has reached epidemic levels, with at least 2.8 million people dying each year as a result of weight-related health problems (WHO 2014). Furthermore, in support of these findings, Dr Carmona Surgeon General, in a study conducted by the American Heart Association,

categorised the threat of obesity as follows: “Because of the increasing rates of obesity, unhealthy eating habits and physical inactivity, we may see the first generation that will be less healthy and have a shorter life expectancy than their parents” (American Heart Association 2014). According to Smith (Smith 2010), we take for granted the many foods presented in supermarkets and specialty shops. Exciting recent research carried out by Brownlee (Brownlee 2010) suggests that, “if we can add the natural fibre from seaweed to products commonly eaten daily – such as bread, biscuits and yogurts – up to three-quarters of the fat contained in that meal could simply pass through the body”, but only if scientific testing by clinical trials is successful in proving that the consumption of bread containing alginates can improve health. Trials on nearly 80 healthy but overweight men revealed that those fed scrambled egg on seaweed-enriched toast felt so full that they consumed 179 less calories per day (Telegraph 2012). Brownlee’s trials were based on sensory analysis responses and observation of the subjects, followed by questionnaires in conducting his analysis.

Alginate drinks were examined and compared in Jensen’s research, and two further studies, in particular, deserve inclusion in this inquiry. Pelkman et al. (2007, cited in Rehm 2009) describe a survey concerning the effects of alginate on satiety, where an alginate/pectin beverage was used to measure dietary restraint in a study of overweight and obese non-dieting female volunteers. The beverage successfully reduced energy intake and significantly reduced carbohydrate intake in the participants of the study. Secondly, supporting research on alginates and satiety was conducted by Jensen (2011). Jensen’s (Jensen 2011) doctoral research, titled *Effect of alginate fibre supplementation in regulation of appetite, body weight and metabolic risk factors*, involved analysis using alginates derived from brown algae that are noted for creating an “artificial feeling of fullness” in the stomach (Jensen 2011). Jensen further expands on his findings, and explains that “Eating more than you burn results in a body energy imbalance, which may lead to weight gain in the long term. It is, therefore, crucial that new dietary measures improve appetite control and limit our food intake” (Jensen 2011). Choosing a seaweed product at breakfast-time, such as a beverage or bread, may well give consumers the “artificial feeling of fullness” in the stomach to which Jensen (2011) refers. The next section examines how alginates may be introduced into the national diet.

2.7 Examining methods of introducing seaweeds into the national diet

Bread is consumed mainly during breakfast. It is eaten mainly as toast or with other products, and this would serve as the ideal time to introduce the daily intake of seaweed products into the diet. Whether eaten during breakfast or in the form of a sandwich taken to school or work for later consumption, there are many opportunities for introducing seaweed into the daily diet using bread or snacks. By examining existing successful methods for the distribution of fortified foods and cereals to the public, it may be possible to mirror the models of successful food businesses to include seaweed in the daily diet in the form of bread, snack bars or pastry items. Multinational companies such as Kellogg's and Nestlé have developed global businesses selling breakfast cereal products that are both fortified and enriched with vitamins. Kellogg's is a multinational consumer goods company with a focus on breakfast cereals and convenience foods; in 2004, Kellogg's net sales reached approximately $9.6 billion USD. (Statistica 2015). Breakfast is a growing market, and this breakfast market segment is now dominated by multinational companies. The morning breakfast market segment could be open to future competition by fortified, nutritious breads. Commercial interests and government incentives already legislate the fortifying of flour, the fortification of salt with iodine and the fluoridation of water for the overall benefit of public health (WHO 2009). Eighty-two countries now participate in cereal fortification worldwide (Food Fortification Initiative 2014) (refer to Figure 2).

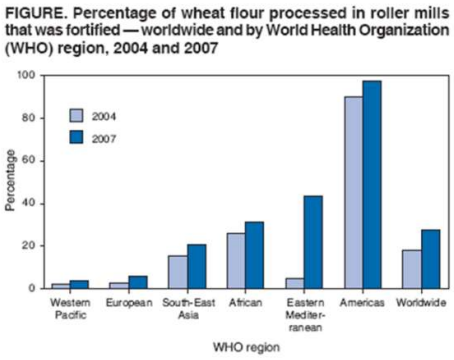


Figure 2: Cereal fortification by quantity per global region during 2004 and 2007

Source: (Centres for Disease Control and Prevention, 2008)

Table 1: UNICEF Flour Fortification Initiative

TABLE. Estimated number and percentage of persons and women who had access to fortified wheat flour and of newborns whose mothers had access to fortified wheat flour during pregnancy — worldwide, 2004 and 2007

Category	Total population	2004 No.*	2004 (%)	2007 No.*	2007 (%)	Change from 2004 to 2007 No.	Change from 2004 to 2007 (%)
Total persons	6,512,822†	1,271,363	(19.5)	1,810,659	(27.8)	539,297	(8.3)
Women aged 15–50 yrs	2,142,225†	410,091	(19.1)	577,461	(27.0)	167,370	(7.8)
Newborns whose mothers had access	133,804§	27,052	(20.2)	41,060	(30.7)	14,007	(10.5)

*In thousands. Calculated from data from the Flour Fortification Initiative, available at http://www.sph.emory.edu/wheatflour.
†In thousands, mid-2006 estimate. From U.S. Central Intelligence Agency, available at http://www.cia.gov.
§In thousands. From United Nations International Children's Emergency Fund (UNICEF) birth rate estimates, available at http://www.unicef.org.

Source: (Centres for Disease Control and Prevention 2008)

Of the 82 countries that require the fortification of wheat flour, maize products or rice:

- 81 countries mandate wheat flour fortification;
- Six states mandate rice fortification;
- 12 countries require maize flour fortification;
- Six countries fortify at least half of their industrially milled wheat flour through voluntary efforts;
- 31% of the world's industrially-milled wheat flour is fortified with iron or folic acid.

In a study that commenced in 2012 (Food Fortification Initiative 2014), it was found that at least 38,417 serious birth defects were prevented in one year due to flour being fortified with folic acid. This equates to 105 healthier babies every day.

The World Health Organization's (WHO) schemes have been very successful to date in delivering nutrients aimed at the wider population base. Vitamins and minerals such as vitamins A, B12, iron, calcium, zinc and folic acid have, for many years, been added by millers to fortify flour and impact positively on public health (WHO 2009). There is further scope to fortify flour with seaweed, either privately, nationally or internationally, in the future. It may be entirely feasible in the future to use the model described above in the provision of seaweed within bread and foodstuffs through cereal fortification. The mechanisms of how flour and other food fortification with alginates could be brought to the consumer marketplace are discussed in the following section. Snacks, breakfast bars,

convenience foods, restaurants and artisan bakeries could all be instrumental in achieving this goal, by adding dried seaweed directly to the food and dough preparation process.

2.8 The delivery of nutrients to the population using flour or bread

Since 1993, when the WHO and UNICEF recommended and implemented universal salt iodisation, many countries worldwide have made substantial progress in the control and prevention of iodine deficiency disorders, largely as a result of salt iodisation (World Health Organization 2014). According to the World Health Organization (2009), the fortification of "industrially processed wheat and maize flour, when appropriately implemented, is an effective, simple, and inexpensive strategy for supplying vitamins and minerals to the diets of large segments of the world's population" (WHO 2009). The negative aspect of having to fortify food to a large population in developing countries is mainly related to the rising over-consumption of highly processed foodstuffs which contain little or no nutritional value (Maberly, et al. 1995).

Once its efficacy has been recognised, seaweed could perhaps be added to some, or all, flour supplies, just as calcium is presently added by law, for the benefit of the population's health. Additional nutrients could be provided to the public through the medium of bread or other widely consumed foods such as cereals, pasta and rice. Research conducted in the UK by leading scientist Dr. Ian Brownlee has incorporated trials using bread made with seaweed, and has achieved some success. Brownlee (Brownlee 2010) states that "bread fortified with the seaweed, eaten regularly with the correct lifestyle, based on very recent research, helps to improve wellness, tackle obesity and many other illnesses which are now attributed to our poor diet and poor lifestyle" (refer to Appendix E). Some of the many health benefits which assist in maintaining wellness are outlined in the next section.

2.9 The health benefits of seaweed consumption

The Food and Health Innovation Service (FHIS 2003) commissioned a study titled "Sea Vegetables for Health". The study was concluded in 2013 by Professor Marcel Jaspers and Dr. Florence Folmer of the Department of Chemistry, University of Aberdeen, UK. They

produced the following list of health benefits associated with seaweed consumption from this research:

- the regulation of blood sugar levels and the prevention and treatment of diabetes;
- the regulation of cholesterol levels;
- a reduction in lipid absorption in the gastrointestinal tract;
- weight loss and anti-obesity effects;
- the prevention of hypertension;
- the prevention of thrombosis and of excessive blood coagulation;
- cardiac health improvement;
- antioxidant effects;
- the promotion of intestinal health;
- the prevention and treatment of arthritis, asthma, rhinitis, gastric ulcers, and other inflammatory diseases;
- the support of healthy joints;
- the prevention of osteoporosis;
- cancer-preventive effects;
- antiviral effects (against HIV and Herpes simplex);
- the promotion of healthy thyroid function and the prevention of goitre;
- prebiotic activities;
- the regulation of bowel function;
- the prevention and treatment of anaemia;
- wound-healing;
- the regulation of hormone balance during menopause;
- detoxification from radioactive elements, heavy metals and free radicals.

(Food and Health Innovation Service 2013, pp.3-4)

The benefits referred to above relate only to the properties researched as regards nutritional benefit in food, but further study has discovered that seaweeds offer other valuable properties, such as natural preservation agents and significant other roles in food preparation (refer to Section 2.10).

2.10 Gastronomic and food-preservation properties of seaweed

The study also found that seaweed acted as a natural thickener and food preservative, as well as several other purposes listed below:

- food thickening, emulsifying, and gelling properties (phycocolloids)
- vegetarian and vegan substitute for gelatine
- substitute for gluten
- natural food colouring
- foam-stabilising properties
- cryoprotection
- moisture preservation in meat and bread; retardation of bread staling
- aroma enhancement

(Food and Health Innovation Service 2013, pp.3-4)

For many vegans, the ability to use alginates instead of gelatine opens up many new avenues for food enjoyment, such as desserts and mousses. Bread preservation and gluten substitution are of major interest to the bakery sector, while aroma enhancement and food thickening are of interest to the broader food and catering sector. In the next section, the scientific findings and benefits of seaweed use in bread are examined.

2.11 Scientific findings concerning the benefits of the use of seaweed in bread

Professor Ian Brownlee and his team began trials using seaweed in bread in 2010. Brownlee's findings are further supported by Parsons, cited in Rae (Rae, 2014), who, along with a team of scientists at Newcastle University, recognised seaweeds that are most efficient at inhibiting the adsorption of fat. Parsons explains that "alginates – chemicals from seaweed – are already used in many foodstuffs". Varied uses include assisting frothy heads in beers and as thickeners in jam manufacture. Their potential as a food supplement, however, is of significant interest. Scientific researches indicating that alginates prevent the absorption of fat in the gut are presently being further investigated by Brownlee (2010). New research published by Brownlee has identified those chemical properties found in alginates which prevent the fat from being absorbed into the body. These findings will allow seaweed

specialists to produce a league table of the most chemically efficient seaweeds for use with foodstuffs. “If added to everyday foods, these seaweeds could help to curb the growing obesity problem” (Brownlee 2010). Parsons (cited in Rae 2014) adds that “Alginates are made up of long chains of sugars, guluronate and mannuronate. Scientists identified that alginates containing more guluronate were more effective at preventing the digestion of fat”. Dr Matthew Wilcox, cited in Rae (Rae 2014), reports, that the seaweeds with a high level of guluronate prevent the body breaking down and absorbing fat. Wilcox states that

> As they are already used in the food industry in small amounts, we are looking at increasing their levels in foods that could reduce the amount of fat that we get which could help in weight management […] The study shows that certain seaweeds can be used in the fight against obesity, in conjunction with a healthy diet and increase in exercise (Wilcox 2014).

The five-year study cost £500,000, and builds on previous work by the team which found that alginate, a natural fibre found in sea kelp, and one of the world’s largest commercially-used seaweeds, could reduce the amount of fat available for absorption into the body by approximately 75% (refer to Appendix E). Pearson, cited in Rae (Rae 2014), supports these findings, adding

> We have already added the alginate to bread and initial taste tests have been extremely encouraging. Now the next step is to carry out clinical trials to find out how effective they are when eaten as part of a healthy diet. A brown sea kelp called tangle or cuvie was found to be the most effective at preventing the digestion of fat. The next step for the team is to test the different seaweeds in a model gut and then to recruit volunteers to study whether the effects they have modelled in the lab can be reproduced in real people and whether such foods are truly acceptable in a healthy diet (Rae 2014).

Rose (Telegraph 2012) has completed food and tasting trials using seaweed bread. The findings are very promising, and were conducted on 80 subjects. The process description is rich in detail, and particularly well described (refer to Appendix E). The earlier research results of Rose (2012), Brownlee (2010), Wilcox (2014) (refer to Sections 2.6, 2.8 and 2.11) were based on sensory analysis, weight loss observation and satiety feedback from the participants. The studies of Jensen (2011) and Houghton et al. (2013) are documented in full (Appendix E). While they both had sensory and satiety elements to their study, they also

incorporated greater scientific data than the Brownlee (2010) study, including blood analysis of the subjects involved in the research, which resulted in quantifiable proof of the fat-inhibiting properties of alginates. In the journal article Houghton et al. (2013) "Treating overweight/obesity using alginate enriched bread", further scientific data was presented by a team of scientists which included Wilcox and Brownlee. The most recent scientific findings from their study indicate that

> obesity is a rapidly growing medical issue worldwide, and is fast becoming one of the leading causes of mortality. Data from our laboratory have demonstrated that alginates have the ability to inhibit pancreatic lipase activity in-vitro, and may therefore reduce the fat absorbed in the diet (Houghton, et al. 2013).

Siggins (2014), in *Irish Times News*, also supports this research, reporting that seaweeds provide protein and vitamins that help to maintain gut health. Seaweeds are also "anti-carcinogenic", and promote better hormone balance in women. Furthermore, according to new research, Siggins adds that seaweed can control "fat deposition" and help with weight management (Siggins 2014). The seaweed market is a global one; most coastal communities, by their nature, are surrounded by water, and have free access to the harvesting of seaweed. The next section investigates both the Irish and the global potential of the seaweed functional food market.

2.12 The seaweed market in Ireland, and its global potential

Today, seaweed is a growing business in Ireland. It is used in many cosmetic products, as well as in food. Ireland's seaweed industry is predicted to increase in value from its 2006 value of €18 million to €30 million per annum by 2020 (Marine Institute of Ireland 2006). A significant contribution to this expansion is derived from cultured seaweed, according to Watson (2011, p.7), although there is an identified need to capitalise on Ireland's existing wild resources. Watson (2011, p.5) also comments that the introduction of mechanical harvesting in Ireland is currently being investigated. This opens up opportunities for new developments, such as functional foods. At a recent conference held in Limerick by Bord Iscaigh Mhara, Siggins (2014) reported that consumers are becoming "more aware of the health and nutritional benefits" of seaweeds. Seaweed farming is now a global business, and

the value placed on the world market of farmed seaweed for human consumption is estimated to be worth €6 billion per annum, a market which is currently dominated by China and Japan. However, the cultivation of just four types of seaweed in Ireland could provide some 100 new jobs along the west and south-west coasts, with a further 80 to 100 jobs in processing (Siggins 2014). In Ireland, seaweed is an under-used food commodity with world export potential. The following section will examine the development of the seaweed business in Ireland, and its export potential.

2.13 Harnessing the national and export potential of Irish seaweed

In 2007, the Marine Institute of Ireland initiated Sea Change, a marine knowledge research and innovation strategy for Ireland during 2007-2013. The policy was aimed at driving the development of marine resources in Ireland in a manner that contributed to the knowledge economy. Research priorities highlighted included the need for the extraction of bioactive compounds and the development of functional foods from seaweeds. The seaweed industry was also highlighted as a research interest in 2011 in the Irish government's initiative to develop an "Integrated Marine Plan for Ireland" to harness the country's "ocean wealth". Ireland's seaweed and biotechnology sectors are estimated at €184 million per annum. There are 36,000 tonnes of wild seaweed harvested per year, and there are currently 185 full-time employees involved (Morrissey et al. 2011, pp.721-727). On this basis, the level of seaweed harvesting in Ireland appears to be set to increase in the future.

The 2011 Bord Iscaigh Mhara (BIM) market analysis report titled *The Further Development of Seaweed Aquaculture in Ireland Report* has outlined the need for the seaweed industry to develop processing in order to add value to its products. It was also noted that substantial technical development is required in the areas of drying, milling and the production of liquid extracts, along with the need for a science-based approach to the development and marketing of novel seaweed products, including functional foods (Watson 2011, pp.5-7). Ireland's seaweed is mainly presented to consumers in traditional forms such as nori, dillisk and carrageen. Nori is used as a wrap for sushi and new forms of "health foods", enticing customers to purchase the product from supermarket shelves.

In the journal *Marine Medicinal Foods*, Se-Kwon-Kim (Se-Kwon-Kim 2011), referring to seaweed, affirms that the well-known relationship between growing consumer interest and functional foods developed using marine sources has been witnessed as a significant business opportunity for the agri-food sector, and, among them, greater potential exists to promote the utilisation of seaweeds in the functional food industry (Se-Kwon-Kim 2011, p.5). One Irish-based company, Connemara Food Ventures Ltd., is presently following this trend, and has begun harvesting, processing and selling seaweed products to the Irish food industry, with a view of exporting in the future. Late last year (October 2014), a new range of dried, milled seaweed-based health food products were launched locally in the west of Ireland city Galway (Ní Fhlatharta 2014) (refer to Chapter 4 and Appendix F). The seaweed product was widely publicised in Connaught by the *Connaught Tribune and City Tribune* newspapers, in articles by Ní Fhlatharta and by Lyons (Lyons 2014) in Cork. The product is also used and supported by the book *Extreme Greens* (2013) written by Sally Mc Kenna, who is based in the Cork area (Lyons 2014).

2.14 Potential hazards concerning the use of seaweed in food

Not all seaweed is suitable for human consumption; Mouritsen (2013, p.68) alerts the reader to contamination in the water within which seaweeds are harvested. Drum (2015) further supports Mouritsen (2013) in "Sea Vegetables for Food and Medicine", adding that seaweed can be contaminated by many pollutants, such as sewage, heavy metals, radiation and cholera. In 2010, the Food Safety Authority of Ireland (FSAI) issued an article advising consumers regarding high levels of arsenic in hijiki seaweed (FSAI 2010). The FSAI alerted consumers with a warning that "Recent sample results from around the world have shown that hijiki seaweed is fundamentally high in inorganic arsenic. As a direct consequence of these findings, the FSAI advises consumers to limit their consumption of hijiki seaweed or choose alternative types of seaweed, where possible". Bruso (2014) supports the FSAI in this view, and has expanded on the potential dangers of seaweed contamination with heavy metals. "If seaweed grows in waters with high levels of arsenic or other heavy metals, it can absorb these metals. Getting too much of them in your diet over time could be deadly. Brown seaweed and the black seaweed called hijiki may be more likely to be contaminated, according to the European Food Information Council. If you purchase seaweed supplements,

look for those that have been tested and verified not to be contaminated with heavy metals" (Bruso 2014).

A recent analysis of dried seaweed samples purchased in London and over the Internet found that some contained worrisome levels of arsenic (American Cancer Society 2008). Bruso (2014) also cautions that seaweed should always be harvested from clean and unpolluted waters. However, due to oceanic tidal currents, seaweed may become contaminated from sources that lie far away from the site of harvesting. An example of this was discovered recently, where, apart from typical pollutants, radiation was detected in samples of seaweed harvested off the Californian coast that was consistent with the radiation released during the Fukushima disaster thousands of miles away in Japan. Bruso (2014) also warns that the consumer should be aware of the source from which the seaweed originated. Cone (2012) supports Bruso's findings concerning the importance of sourcing seaweed for human consumption in non-polluted waters. Cone's earlier findings from readings of kelp samples were taken from the Californian coast, and were examined both prior to and following the Fukushima disaster.

> The level of radioactive iodine found there – 2.5 Becquerel per gram of dry weight – was "well above" levels sampled in kelps prior to the Fukushima release, according to the paper, published online earlier this month in the journal Environmental Science & Technology (Cone 2012).

In addition, the New South Wales government issued a warning to pregnant and breastfeeding women in particular concerning the dangers of consuming certain seaweed soups, some of which contained over 33 times the RDI of iodine, which could prove harmful to the unborn foetus or the breastfeeding child (NSW Ministry of Health 2010). While dangers exist for the over-consumption of seaweed with high levels of sewerage pollution, iodine or radiation, proper sourcing and consumption of seaweed can eliminate this danger. In the following section, the researcher has included 10 reasons for which seaweed should be included in the diet (refer to Table 2).

2.15 Chapter conclusion

To conclude the chapter, the researcher begins by including a table from the FSAI (2012) that gives ten reasons why seaweed should be consumed regularly. The table reinforces some of the main nutritional qualities of seaweed and the benefits to both health and the environment arising from their use.

Table 2: Why consumers should consume seaweed

1)	Algae are of low calorific value and hence suitable food sources during weight loss and weight management diets.
2)	Algae are suitable and complementary to vegetarian, vegan, and low calories diets, and conform to Kosher regulations (alginates, agar, and carrageenans are excellent gelling agent alternatives to gelatin). Algae provide vitamin B12 which tends to be low in vegan and vegetarian diets.
3)	Algal products can be used as substitutes for gluten in gluten-free foods.
4)	Algae are a rich source of iron and of iron bioavailability-enhancing vitamin C.
5)	Algae are a rich source of iodine and hence have the ability to help prevent and treat hypothyroidism and to protect against health damage caused by nuclear radiation.
6)	Algae have a low salt (NaCl) content and are a good salt substitute with rich sea salt-like flavours.
7)	Algae possess numerous bioavailable nutraceutical compounds with health-beneficial properties including hypoglycemic, hypocholesterolemic, anti-obesity, cardioprotective, anti-oxidant, anti-inflammatory, anti-cancer, anti-viral, and immune-stimulant properties.
8)	Algal products can be easily integrated into common food such as bakery products, pasta, etc. without affecting the taste or texture of the food.
9)	Algae grow fast compared to agricultural plants, and they are well suited to the British climate. Algae grow in the ocean, solving issues of freshwater supply and arable land availability, as the U.K. possesses a large coastal area.
10)	Algae are low-cost, highly nutritional alternative to soy and other protein crops. They are also an environment-friendly alternative to tropical palm trees for cooking oil, spread, confectionery, chewing gum, and chocolate spread production.

Source: (FSAI 2010, p.20-21).

The use and benefits of seaweed in food have been introduced in this chapter. A brief history of the application of seaweed use in Ireland and Asia was outlined. The main types and uses of seaweeds for human consumption were also listed, while the increasing popularity of seaweed consumption in Western culture was noted, and examples of its use in culinary application were mentioned. The research was developed and expanded by outlining the use of seaweeds in beverages and broader food applications. The research was further segmented to examine the health aspects of seaweed and the introduction of seaweed trials using baked goods and beverages. Methods were discussed and examined in regard to how seaweeds could be introduced into the national diet. Using proven methods endorsed by the WHO and UNICEF, the successful delivery of nutrients such as calcium, iron, folic acid and vitamins through flour fortification and the iodisation of salt was discussed. The successes of some of

these programmes were listed, and the research briefly examined how seaweed nutrients could be sold to consumers in baked goods, based on trials conducted by Brownlee (2010). The health benefits of seaweed consumption were outlined, and food preservation was listed and discussed. The findings of clinical and scientific trials conducted using alginate drinks and seaweed breads were explored, while the role that alginates could play in the fight against obesity when consumed in foods was discussed and analysed.

As an island nation, Ireland is surrounded by the sea, and the research investigated how it may be possible to better harness the seaweed resources currently available. Research conducted by the Marine Institute of Ireland indicated that the seaweed industry has the potential to become a multimillion euro business for the domestic use and export of seaweed for foodstuffs. A start-up business was found to be manufacturing a dried seaweed product in Connemara for the bakery and catering business. The hazards concerning seaweed consumption were also identified and discussed, with particular reference to pregnant and breastfeeding mothers. Finally, 10 reasons for which more seaweed should be consumed were listed.

In summary, four themes were evident during the course of the research. Firstly, seaweed has been a part of the daily human diet for thousands of years; in particular, its importance has always been recognised more in Asia than in Western culture. Secondly, seaweeds are a plentiful source of food and nutrition, and are a very much an underutilised natural resource. Thirdly, there is great potential in regard to both the nutritional findings and the health benefits that regular consumption of seaweed can bring to the consumer. Fourthly, the scientific findings indicate that seaweed, if incorporated into bread and alginate drinks, could facilitate a reduction of many modern illnesses, such as cholesterol, thyroid problems, heart disease and obesity.

Chapter Three: Methods and Methodology

3.1 Introduction

Goddard and Melville (2001, p.1) describe research as "not merely a process of gathering information, as is sometimes suggested. Rather, it is concerned with answering unanswered questions or creating an area of study which does not currently exist". In this study, there was a distinct lack of recipe information available for baked goods using seaweed. Thus, using the manufacturer's guidelines, a range of seaweed products were developed for the study, and research was conducted in regard to sales, and perceptions of their appearance and the concept itself. The concepts were outlined in the questionnaire design and supplemented with photographs of prototype products. "In many ways, research can be perceived as a process of expanding the boundaries of our ignorance" (Melville 2001, p.1). The purpose of this chapter is to explain the various methods available to analyse and collect data, to indicate what is meant by primary and secondary data, and to explain and justify the chosen research methods. The research questions are outlined and explained, while the reliability and validity of the study, and its relevant ethical considerations, are also addressed.

3.2 Research topic and design

"Interest in a particular topic usually begins the research process, but it is the familiarity with the subject that helps define an appropriate research question for a study" (Haynes, 2006). As the consumption of seaweed is not commonplace, the survey was designed to measure the reaction of a broad demographic to the concept of eating seaweed in foods such as bread, pastries and snack bars. The research topic was as follows: "An investigative study into the beneficial use of seaweed in bread and the broader food industry". The study was investigated both by way of an online survey and via the performance of sales of seaweed products developed for the study, which provides the framework for the research question. According to Sekaran and Bougie (2009, p.102), a research design is the most important step in gathering and analysing relevant data and in determining the location of the study, the sample size, the population, and so on.

Five seaweed products were developed for the study; sourdough bread, baguettes, soda bread, laminated pastry and flapjacks. The questionnaire design consisted of 25 questions, each chosen to gain specific data from the respondents. The questions sought information regarding a varied range of topics, each connected to the research question, such as the age of the respondents, their geographical area, demographics and the reaction of those respondents to pictures of actual seaweed-baked goods. The objective was to identify the respondents' knowledge, the potential future users of seaweed products, their age, gender, demographics, attitudes towards health, nutritional habits and typical weekly spend on bakery products.

3.3 Sources of data

Data can be obtained both from primary and secondary sources. Primary data is that which has been collected for the sole purpose of the project at hand. It does not exist already, and is unique to the particular research question itself, having been gathered personally by the researcher. Data collection can also be achieved by way of face-to-face interviews, telephone interviews, questionnaires and focus groups. Secondary data, meanwhile, refers to information that already exists, such as published academic papers, company websites, government publications and industry analyses (Sekaran and Bougie 2010).

3.4 Quantitative research

According to Denscombe, (Denscombe 2014), there are four main factors required when pursuing the quantitative approach: the validity of the data, the reliability of the methods, the external validity and the objectivity of the researcher (Denscombe 2014, pp.271-272). Bryman and Bell suggest that quantitative research is a distinctive research strategy; it entails the collection and analysis of numerical data, and is described as involving the collection of numerical data to exhibit a deductive view of the relationship between theory and research (Bryman and Bell 2011). Bryman and Bell also indicate that there are four distinctive preoccupations regarding quantitative research: measurement, causality, generalisation and replication. In this study concerning seaweed, all of the principles above have been incorporated. The basic premise of quantitative research involves examining numbers and viewing their relationship with published theory. Simply stated, it is common for outlines of

the main steps of quantitative research to suggest that a hypothesis be deduced, in theory, which is subsequently tested through research.

Researchers will aim to ensure that the results are as representative as possible of a whole group, as opposed to only the group that has directly participated in the survey. Causality deals with the investigation into why a particular occurrence happened, and attempts to explain it. Quantitative researchers are more interested in the "why", as opposed to the "how". It is also important that the results obtained in a survey can be generalised outside of that particular study. Finally, it is imperative that it is possible to replicate the results of a body of research. This is necessary in order to protect the validity of the original findings (Bryman and Bell, 2011).

3.5 Qualitative research

Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study features in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people attach to them. Qualitative research involves the studied use, and collection of, a variety of empirical materials – case studies, personal experiences, introspective accounts, life stories, interviews, observational data, historical information, interactional accounts and visual texts – that describe routine and problematic moments and meanings in individuals' lives (Denzin and Lincoln 2005, p.2). Qualitative research mostly deals with the generation, as opposed to the testing, of theories (Bryman and Bell 2011). The marketplace in which the potential to sell healthy bread and measure consumers' attitudes to healthy additives in bread was also investigated. The information was developed based on research undertaken by An Bord Bia (2014) (refer to Appendix D).

3.6 Case study

A case study approach was not used in this instance to carry out the research for the project. It was viewed as being both unsuitable and too large an undertaking, considering the resources available and the time frame remaining for the study. Yin (2009), a recognised leader in case study methods, emphasises that case studies may also be useful for explaining

presumed causal links between variables (e.g., treatment and intervention outcomes) which are “too complex” for survey or experimental designs. Furthermore, they may describe the real-life context of a causal chain, illustrate specific constructs and illuminate a situation when outcomes are not clear (Yin 2009).

Whilst research is generally carried out using either qualitative or quantitative methods, Neuman (Neuman 2003) suggests that research would benefit from using both qualitative and quantitative methods. As regards this research project, it was felt that using the quantitative method (involving, for instance, sales figures for the new products developed) combined with survey results would produce the most accurate results for this particular study, as it was focused on a broad cross-section of people. Babbie (Babbie 2010) suggests that quantitative methods emphasise objective measurements and the statistical, mathematical or numerical analysis of data collected through polls, questionnaires and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalising it across groups of people, or using it to explain a particular phenomenon.

3.7 Data collection

This study was framed by the collection of primary data from the actual localised sales of seaweed products, combined with an online survey involving a larger demographic group. The data did not exist prior to the research, and the sales data was gathered over a six-month period. The survey data, meanwhile, was collected over a period of two weeks. The data gathered for the primary research was collected through an electronic survey, using the online SurveyMonkey tool. The participants living in Ireland were further segmented with the inclusion of a question regarding the provincial area in which they currently resided. The secondary data in Chapter 2 was framed by a comprehensive review of books, journals, websites, newspaper articles, conference proceedings and semi-state bodies. Drawing on the information resource collected in Chapter 2, the frameworks of methodology in Chapter 3 and the sales data gathered in Chapter 4, the research questionnaire was prepared. Using the information from the aforementioned sections, the survey was designed to seek specific data relating to public opinion, acceptance or rejection of the potential health benefits of seaweed use in food.

3.8 The reliability and validity of survey data

In assessing reliability and validity, it is essential to observe that Bryman and Bell (2011) state that reliability and validity are extremely important to the area of research, and that, if a measure is not reliable, it cannot be valid. In order for a piece of research to be considered robust, it simply must be reliable and valid (Kirk and Miller 1986, p.19). In support of Bryman, LeCompte and Goetz (1982, p.32) offer a further definition: "While reliability is concerned with the replicability of scientific findings, validity is concerned with the accuracy of scientific findings". Furthermore, Kirk expands on the validity of gathered data: "Loosely speaking, reliability is the extent to which a measurement procedure yields the same answer however and whenever it is carried out; validity is the extent to which it gives the correct answer" (Kirk and Miller 1986).

Last (Last 2001) also highlights the issue of threats to validity and reliability: "Threats to a study's validity and reliability exist at almost every turn in the research process". In this context, it is important to ensure that protocols are designed and followed to minimise the threats faced. LeCompte and Goetz (1982) add to the views concerning validity and reliability by stating that, when addressing the issues of reliability and validity, it is important to view them in the context of "internal" and "external" design issues. External reliability deals with whether independent researchers would discover the same information in the same, or similar, settings, whereas internal reliability refers to the degree to which other researchers would arrive at the same conclusions as the original researcher given the same data set and conditions. To ensure that both external and internal reliability were addressed, all data, including the recipes for the products featured in the survey, are set out in detail (refer to Appendix H). In this regard, a bakery researcher could follow the steps required to reproduce all of the data required to emulate this study.

3.9 Ethical considerations

It is important to ensure that, during the course of the research, the trust placed in the researcher is respected at all times, and that no harm is caused to the participants. It is also vital that there is no invasion of privacy, that there is no deception and that there is always informed consent in relation to the research activities (Diener and Crandall 1978). As defined

by Cooper and Schindler (1998, p.180), ethics can be described as "the norms or standards of behaviour that guide moral choices about our behaviour and our relationships with others". The online survey used for the collection of this data was a completely anonymous application, protecting the identities of all participants in the survey. As a student in the School of Culinary Arts and Tourism at Dublin Institute of Technology, the researcher's study was also conducted under the guidelines laid down by Dublin Institute of Technology's Code of Research Ethics. Confidentiality and anonymity were guaranteed to all respondents (refer to Appendix I).

3.10 Limitations

The author has selected SurveyMonkey over other methods of data collection, due to the limitations of time, accuracy and financial constraints. For a small fee, SurveyMonkey gathered all of the data together into one report, saving the author a great deal of time. The methodology consisted of a questionnaire containing 25 questions. The survey was distributed using Facebook and email as the method of engagement.

The sales figured of seaweed products were gathered on the EPOS system of the researcher's bakery store over a six-month period, and represent a very small percentage of sales and local demographics. The target sample for the study consisted mostly of people living in Ireland. While the author was most interested in their views and opinions, in the interests of multi-cultural balance, bias and a more global view of opinion, respondents of other nationalities also participated. As Facebook is an international medium by which to conduct a survey, provision was made to include other geographical regions, including the United Kingdom, Europe and the United States. The author believes that the combined population and geographical mix factors involved could distort the results of the survey due to differing cultures and tastes.

Sensory analysis, for example, could be used for further study in the future, such as at master's degree level. Interviews were not conducted, due to time limitations. There was insufficient time to conduct an in-depth survey, nor would this method have been successful without substantial financial resources. The author expects that the results of the study will prove to be an honest, clear and valid snapshot from a consumer perspective. The combined

methods chosen safeguarded, that the research question was addressed, validated and answered. (Refer to Last (2001), and LeCompte and Goetz (1982)for supplementary evaluation of research methods.)

3.11 Chapter conclusion

In this chapter, the research design was outlined. The sources of data were explained, and the various research methods available were stated, identified and explained. The choices were justified, in terms of how they fulfilled the objectives of this study. This chapter defined both the research topic and the methodology used to undertake the study. Reliability and validity issues have been addressed, as well as ethical issues. The quantitative approach has been adopted for this segment of the dissertation, as it is particularly well-suited to the study of a broad cross-section of consumers of differing age, gender and social background. The credibility of quantitative data depends on how effective the research methods are at producing data that is accurate and consistent. In all, 172 responses were received from the questionnaire results with an assortment of differing demographics. The results provided a snapshot of people and their opinions, which, combined with the research in Chapter 2 and the findings in Chapter 4, should provide a fair and unbiased result. The limitations of the study were explained and justified according to the researcher's time and resource limitations.

Chapter Four: Results and Discussions

4.1 Introduction

This chapter will collate, analyse and discuss the data collected from the primary research, the secondary research and the researcher's own test bake trials. The researcher was unable, at the beginning of his study, to source any baked products made with seaweed in Ireland. A chance meeting with a director of Connemara Food Ventures Ltd. led to the discovery of samples of an Irish-made seaweed powder. The researcher used this product, which was initially called ARON Seaweed Powder, for a series of test bakes over a 20-week period from September, 2014 to January, 2015. A soda bread recipe was developed for Connemara Food Ventures Ltd (refer to Recipe 1 and Appendix G). In addition to this, the researcher developed several recipes and new product lines for this study, incorporating seaweed into bread, pastry and flapjacks. The recipes used were the standard recipes available to all students and lecturers in the School of Culinary Arts and Hospitality Bakery programme at DIT, Cathal Brugha Street, Dublin. The recipes incorporated were used to create baguettes, sourdough, flapjacks, soda bread and croissant pastries. These recipes were used so that others could reproduce the research by following the manufacturer's guidelines (refer to Section 4.2) for seaweed addition in baked goods (refer to Appendix F). The products were photographed and sold in the researcher's retail bakery (Appendix H).

Quantitative research was gathered from an online survey and analysed through SurveyMonkey to yield statistical results. The results are displayed in figures, charts and graphs (refer to Sections 4.5 to 4.29). The figures, graphs and charts collate the data in a visual form, which will assist the reader in gaining a deeper understanding of the results. The overall outcomes of the findings are discussed in the conclusion. Data was also collected from the researcher's sources, the secondary research of the literary review, pooled with the data from the primary research. The three sources function together to triangulate the data, in the hope of ensuring the fulfilment of the aims and objectives of the study.

4.2 Commercial use of NORI Bake Pro in Irish bakery products

Connemara Ventures Ltd.'s product NORI Bake Pro is a blend of dried and milled seaweed powders. It is used as a natural bread improver. It health bar, named SMRT Bar, also contains seaweed as one of its primary ingredients. The SMRT Bar is composed of natural ingredients, with the addition of seaweed in the form of a tasty snack. These products were featured in an article contained in the regional *Connaught Tribune* newspaper (Ni Fhlatharta 2014, p.25).

Figure 3: NORI Bake seaweed bread additive

Source: Connemara Ventures Ltd.

Figure 4: SMRT Bar

Source: Developed for this study

NORI Bake Pro is currently being used in artisan bakeries in Ireland. Mr. Declan Ryan managing director of Arbutus Breads in Cork is a currently using the Nori Bake product, and remarks thusly: "As you know, we have introduced NORI bake sourdough to the market and if you haven't tried it, it tastes the same as our normal sourdough, but with added nutrients and anti-staling" (Ryan 2015).

Figure 5: Commercial application of seaweed in bread (2015)

Source: Connemara Ventures Ltd.

The recommended quantity of NORI Bake Pro to be added to bread recipes, as outlined by the manufacturers, is 3% of flour weight, but this can vary at the baker's discretion. Cost-effectiveness is also a consideration when determining the quantity, as the product costs €15 per kg. Using 3% seaweed per 100% weight of flour allows greater liquid absorption and reduces the cost to an acceptable level for commercial production. While these levels permit a higher degree of hydration in the bread dough, they do not overpower the flavour of the baked product. Regular hydration levels for soda bread are in the 85-87% range for standard Dublin Institute of Technology (DIT) brown soda recipes. The hydration levels increase dramatically when seaweed powder is added in accordance with the manufacturer's instructions (refer to Figure 6).

Brown Soda Bread DIT

INGREDIENTS	Bakers% 1 MIX Kg / g	H2O% Based on 100% 2,000	87.50
100% Wholemeal Flour	1,000	50 %	
Soft Flour	1,000	50 %	
Sugar	50	3 %	
Cream Powder	60	3 %	
Bread Soda	40	2 %	
Vegtable Oil	60	3 %	
Salt	30	2 %	
Buttermilk	1,750	88 %	
Total Weight	3,990		
YIELD SODAS	6		
SCALING WT in grams	650		

Brown Soda Bread with Seaweed

INGREDIENTS	Bakers% 1 MIX Kg / g	H2O% Based on 100% 2,000	147.25
100% Wholemeal Flour	1,000	50 %	
Soft Flour	1,000	50 %	
Sugar	50	3 %	
Cream Powder	60	3.0 %	
Bread Soda	40	2.0 %	
Vegtable Oil	60	3 %	
Salt	15	1 %	
ARON Seaweed Powder	60	3 %	
Buttermilk	2,945	147.25 %	
Total Weight	5,230		
YIELD SODAS	8		
SCALING WT in grams	650		

Figure 6: Hydration levels breads: control compared to NORI Bake Pro recipe

Source: Developed for this study

The bread recipes compare standard soda bread to soda bread fortified with NORI Bake seaweed. The first recipe is a standard recipe for brown soda bread from the DIT baking programme, and is compared with the second formula, which contains a 3% addition of NORI Bake Pro. The hydration levels, when compared with the two examples, provide an indication of the greater hydration levels achieved using the NORI Bake Pro product. The potential uses of this product in baked goods are considerable; recently, the author created a range of sweet, laminated, yeasted pastries, with promising results. The dough, when mixed, has the appearance of poppy seed dough as mentioned by Rose in (Telegraph 2012), (refer to Appendix E, Study 1). The dough can be laminated easily with butter to produce a range of pastry items that are pleasing to the eye for end consumers (refer to Figure 16, Appendix G).

4.3 Dough appearance, and applications using dried seaweed

The bread and pastry dough created using 3% of NORI Bake Pro seaweed has an appearance similar to that witnessed in dough with the addition of poppy seeds. The dough can be baked into many shapes to highlight the bread's seaweed content and entice consumers to purchase, from both an aesthetic and a nutritional perspective (refer to Appendix G).

.

4.4 Online survey using the collection tool SurveyMonkey

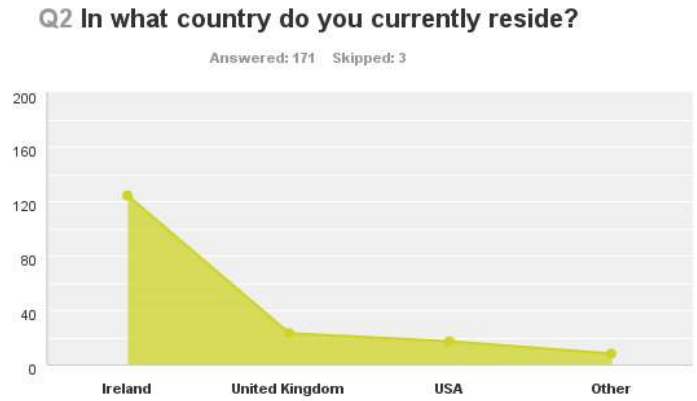
Drawing from the resources which were investigated in Chapter Two, 25 questions were prepared for inclusion in the online survey. The questions were selected to broaden both the depth of study and the validity of the data. The questionnaire was compiled and distributed electronically via both Facebook and email. The Facebook page used to distribute the questionnaire had 8,099 followers at the time it was circulated. It was also distributed to all four years of bakery students currently studying in DIT at Cathal Brugha Street. The target population mostly consisted of people living in Ireland. However, Facebook crosses all international boundaries, and so international participation in the survey was obtained. The objective of the survey was to measure the knowledge and reaction of consumers to the use of and the health benefits of seaweed in food. The data collected permitted the author to investigate a wide-ranging cross-section of respondents from all areas of life. The validity of

the data was important to the author at all times. This method of data collection was justified over other methods, as it was deemed valid and unbiased.

4.5 Demographic information

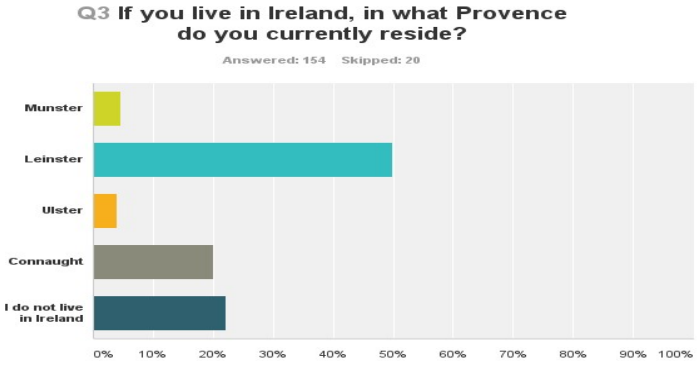
- Of the 174 people surveyed, 63.79 % were female, and 36.21% were male.

- The majority of respondents resided in Ireland (72.51%), with the UK (13.45%), the USA (9.94%) and other countries (4.68%) also featuring.



Graph 1: Summary, nationalities

Source: Developed for this study



Graph 2: Summary, where respondents' reside

Source: Developed for this study

The ideal target group for this study was found to be Irish or from the UK. The results of the survey were reliable, with tastes and opinions from an Irish perspective weighing most heavily in the final outcome of the research questions.

- In regard to the geographic spread of the respondents, 50% resided in Leinster, 22.08% lived abroad, 20.13% resided in Connaught, 4.55% resided in Munster and 3.90% lived in Ulster.

With almost 50% of the population residing in Leinster, the author has no concerns regarding the validity of the survey based on resident location.

- 50.89% of respondents were found to reside in coastal areas, while 49.11% did not.

There was a very slight majority of respondents residing in coastal areas. This could have a bearing on the survey result, as coastal dwellers are generally familiar with seaweed and seafood.

4.6 Summary, whether coastal dwelling respondents were influenced by seaweed foods

- Respondents were asked whether they thought that living in a coastal area would influence them more towards food choices of seaweed foods. 53.85% indicated "yes", while 46.15% selected "no".

There was a slightly greater majority of respondents who indicated that they may be more influenced by seaweed foods based on their proximity to the sea.

4.7 Summary, whether respondents consume nutritional supplements

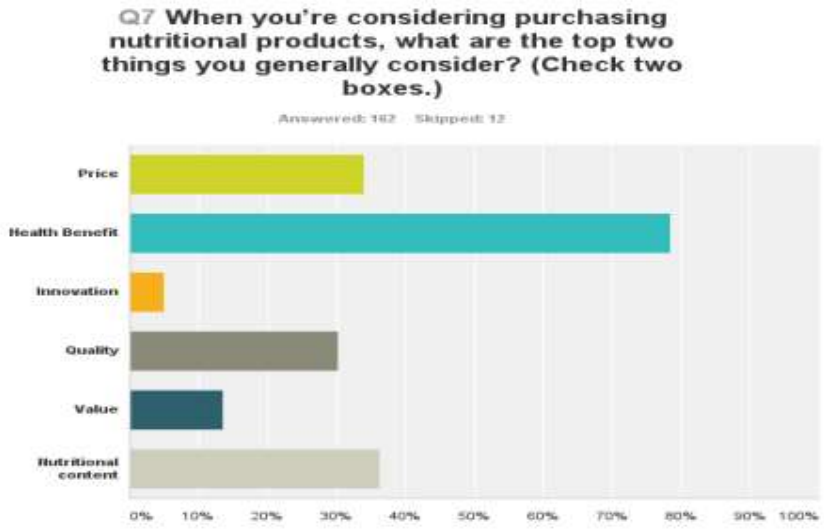
- 58.96% of candidates did not take additional nutritional supplements, while 41.04% did.

The 41% of respondents who consumed nutritional supplements, while in a minority, would represent the more receptive candidates to the marketing of a seaweed product.

4.8 Summary, nutritional product choices that influence purchasing decisions

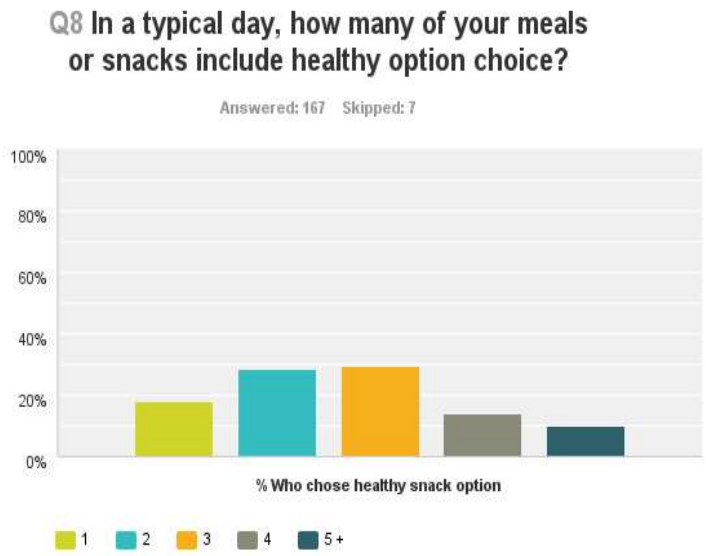
- The top considerations affecting the purchasing decisions of the respondents were related to health benefit (78.40%), with nutritional content (36.42%), pricing (33.95%), quality (30.25%), value (13.58%) and innovation (4.94%) also being selected.

Health benefit scored highest in this question, indicating that consumers place a high value on the health benefits of the foods they choose. This is indicative of consumer bread choices revealed in Bord Bia (2014a, p. 7 and 21) (refer to Appendix D).



Graph 3: Summary, respondents' purchasing nutritional products

Source: Developed for this study



Graph 4: Summary, Frequency of daily healthy food choices

Source: Developed for this study

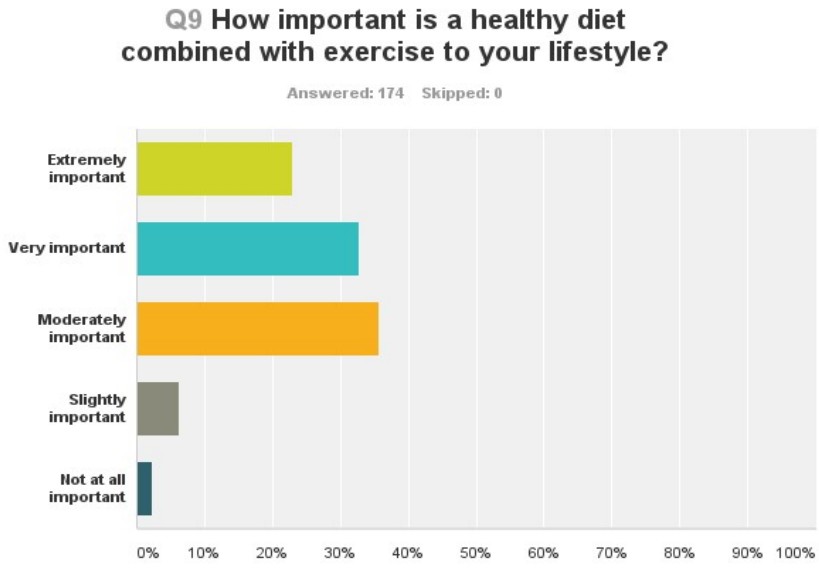
4.9 Summary, frequency with which respondents included a daily healthy food option

- 29.34% of interviewees did so three times per day, while 28.74% indicated twice per day, and 17.96% once per day. 13.77% were associated with four times per day, while 10.18% claimed to embrace healthy options five times per day.

The response to Q.8 demonstrates that most of those surveyed made daily healthy option choices, and have concern and control over their healthy food choices. This is also reflective of consumer bread purchasing in Bord Bia (2014a) (Appendix D).

4.10 Summary, importance of a healthy diet combined with exercise

- 35.63% stated that this was moderately important, while 32.76% indicated "important", 22.99% selected "extremely important", and 6.32% opted for "slightly important". A very small percentage (2.30%) claimed that it was not at all important.



Graph 5: Summary, importance of healthy diet combined with exercise

Source: Developed for this study

The response to Q.9 is indicative that the public perception of a healthy diet combined with regular exercise relates to a large majority (refer to (Poots 2011) in Section 2.4).

4.11 Summary, whether respondents had ever consumed a seaweed product

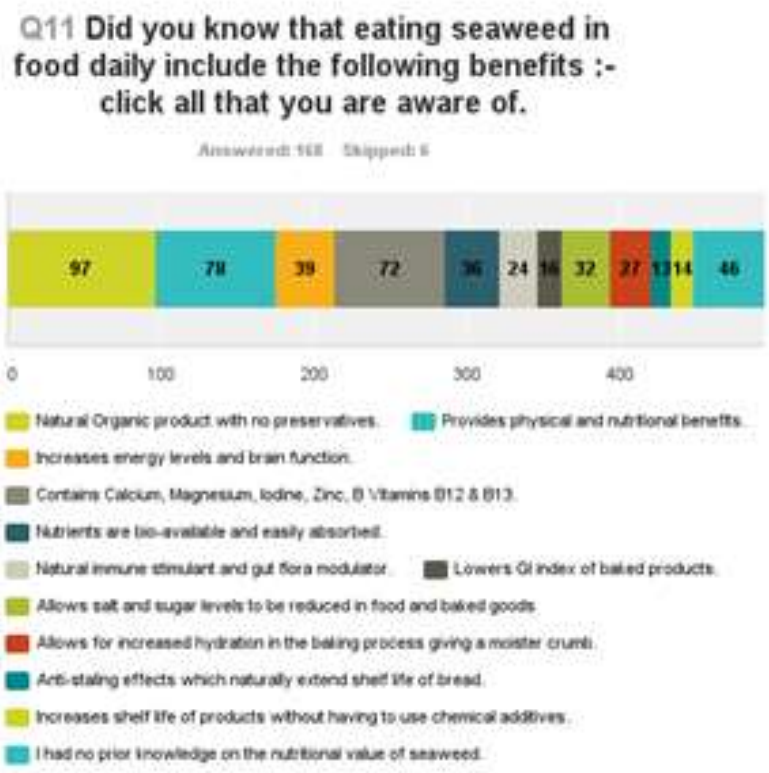
- 71.60% of respondents indicated “yes”, while 28.40% answered negatively.

A surprising majority had consumed a seaweed product, based on figures quoted in FHIS. The results of this question exceed by 5% the average figures according to Honkanen (2009) and Edwards et al. (2012), cited in Food and Health Innovation Service (2013, p.16), which state that over two thirds of the general public in the Western world have eaten seaweed at least once.

4.12 Summary, prior knowledge of health benefits from seaweed consumption

- The respondents were asked a range of questions to measure their knowledge concerning the health benefits of consuming seaweed. The respondents were requested to select all of the choices of which they already possessed prior knowledge.

Table 3: Previous knowledge of the beneficial advantages of consuming seaweed



Source: Developed for this study

Table 4: Consumption of seaweed benefits known to respondents

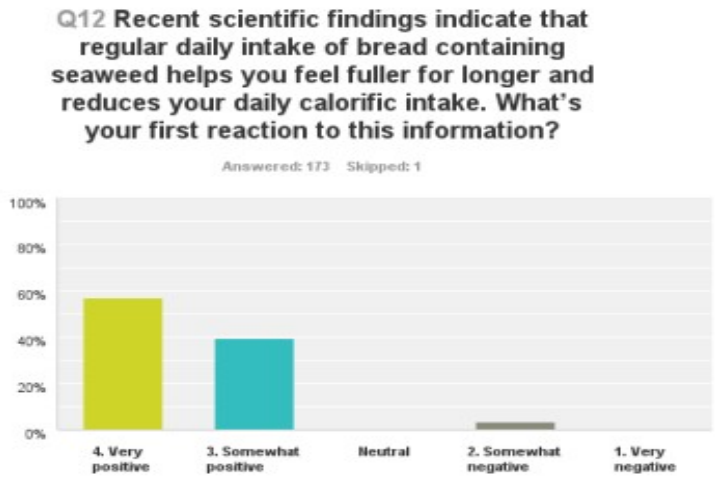
• Natural Organic product with no preservatives.	• 57.7%
• Provides physical and nutritional benefits.	• 46.4%
• Increases energy levels and brain function.	• 23.2%
• Contains Calcium, Magnesium, Iodine, Zinc, B Vitamins B12 & B13.	• 42.9%
• Nutrients are bio-available and easily absorbed.	• 21.4%
• Natural immune stimulant and gut flora modulator.	• 14.3%
• Lowers GI index of baked products.	• 9.5%
• Allows salt and sugar levels to be reduced in food and baked goods	• 19.0%
• Allows for increased hydration in the baking process giving a moister crumb.	• 16.1%
• Anti-staling effects which naturally extend shelf life of bread.	• 7.7%
• Increases shelf life of products without having to use chemical additives.	• 8.3%
• I had no prior knowledge of the nutritional value of seaweed.	• 27.4%

Source: Developed for this study

The results of Q.11 support the view that the majority of the respondents possess knowledge of the nutritional and health benefits of seaweed.

4.13 Summary, seaweed bread makes one feel fuller for longer

- The reaction to the scientific data which claims that, by eating seaweed in bread, one feels fuller for longer, was measured. 57.23% were very positive, while 39.31% were somewhat positive and 3.47% were somewhat negative.



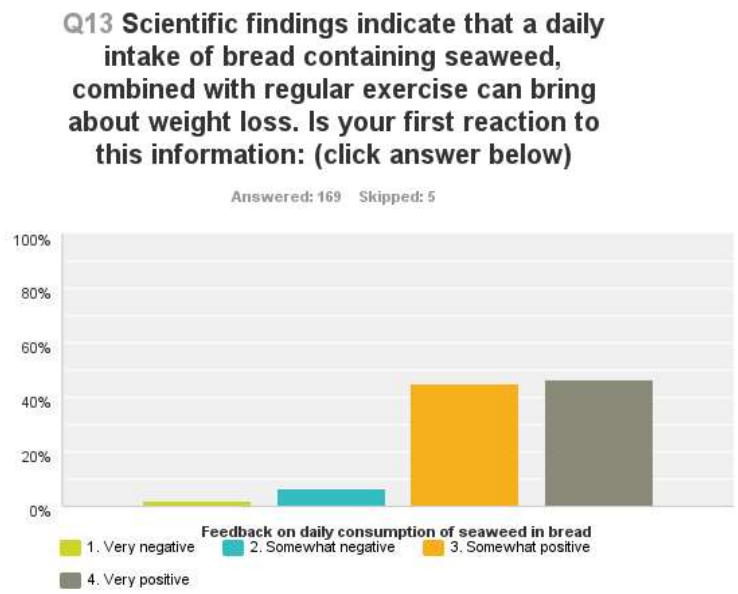
Graph 6: Summary, seaweed bread makes one feel fuller for longer

Source: Developed for this study

The results to Q.12 are very encouraging, and demonstrate that the respondents were very responsive to the idea of satiety being maintained by consuming seaweed, as discussed by Brownlee (2010) and Rose (2012) (refer to Sections 2.4 and 2.5).

4.14 Summary, seaweed bread combined with exercise can lead to weight loss

- 46.75% of the respondents were very positive, while 44.97% were somewhat positive, 6.51% were somewhat negative and 1.78% were very negative.



Graph 7: Summary, seaweed bread combined with exercise can bring about weight loss

Source: Developed for this study

Clearly, the idea of consuming the correct balance of foods and combining diet with exercise to achieve weight loss is of interest to the majority of respondents. This aspect was highlighted earlier by Poots (2012), detailed in Section 2.4.

4.15 Summary, perceptions of a seaweed baguette's appearance

- The response to the pictures of actual seaweed products were very positive for 65.09%, with 33.14% somewhat positive, 1.18% somewhat negative and 0.59% being very negative.

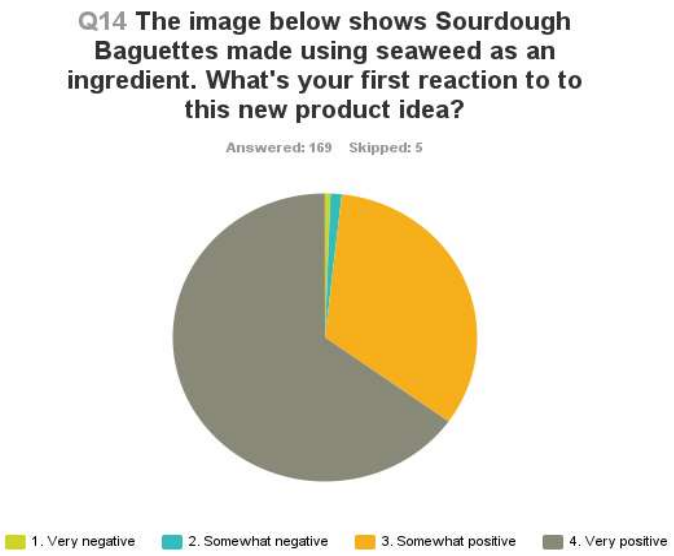


Figure 7: Summary, to images of seaweed baguette

Source: Developed for this study

The 98% result achieved in Q.14 indicates that creativity of presentation is most important in "selling" a seaweed product to consumers. Seaweed is subject to negative connotations, according to Myslabodski (2003), cited in Fisheries and Aquaculture Department (2003) (refer to Section 5.6): "weeds are something we do not want, seaweed implies something negative about the product". Basically, the logic of "If it looks nice, it will taste nice" prevails.

4.16 Summary, reactions to seaweed Danish pastry images

- The reactions to the images of actual seaweed Danish products were very positive for 65.06%, with 27.71% being somewhat positive, 6.02% somewhat negative and 1.20% very negative.

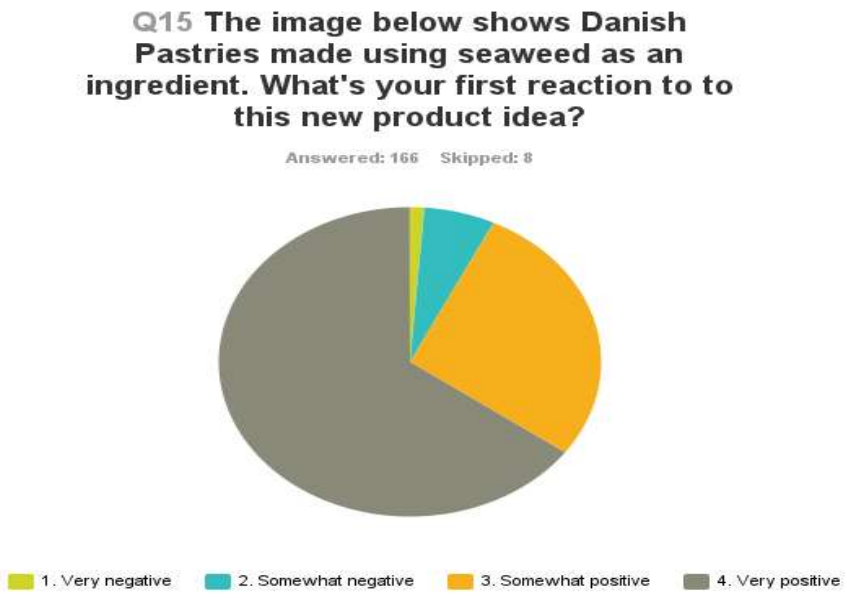


Figure 8: Summary, images of Danish pastries made with seaweed

Source: Developed for this study

The results of Q.15 indicate more negative views among customer perceptions of Danish pastry made with seaweed. Negative sentiment rose sharply to 7.22% among those surveyed, when compared to that related to the baguette (1.77%).

4.17 Summary, seaweed soda bread images

- The reaction to the images of seaweed soda bread products was generally very positive for 54.88%, while 37.20% were somewhat positive, 6.71% somewhat negative and 1.22% very negative.

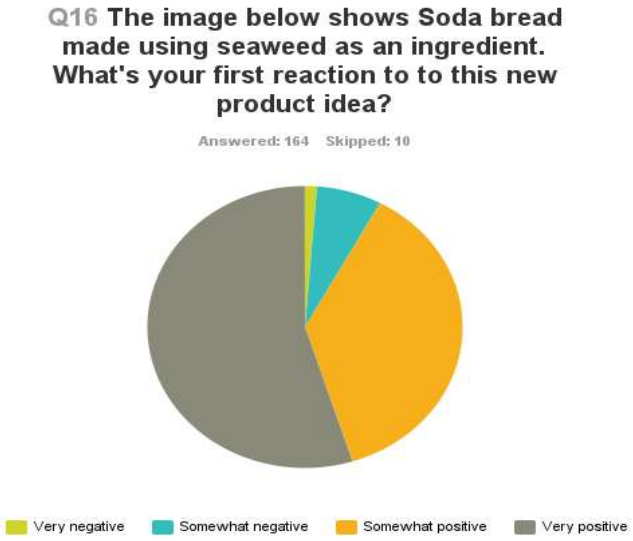


Figure 9: Summary, soda bread made with seaweed

Source: Developed for this study

The results of Q.16 indicate an even more negative view in regard to customer perceptions of soda bread made with seaweed. Negative sentiment rose sharply to 7.93% of those surveyed, when compared to that associated with the baguette (1.77%) or Danish (7.22%).

4.18 Summary, reactions to seaweed flapjack images

- The reaction to the images of seaweed flapjack products was very positive for 54.12%; 34.71% were somewhat positive, 10% somewhat negative and 1.18% very negative.

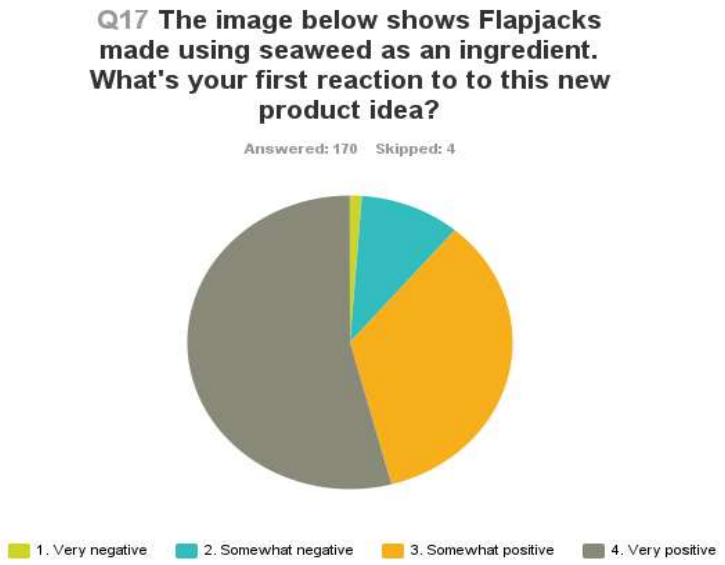


Figure 10: Summary, flapjacks made with seaweed

Source: Developed for this study

The results of Q.17 indicate an even more negative view of flapjacks made with seaweed. Negative sentiment rose dramatically to 11.18% for flapjacks, compared to 7.93% for soda bread, Danishes (7.22%) and baguette (1.77%).

4.19 Summary, perceptions of seahorse baguette images

- The response to the pictures of seahorse seaweed baguette products was very positive among 62.05%, with 31.33% somewhat positive, 4.82% somewhat negative and 1.81% very negative.

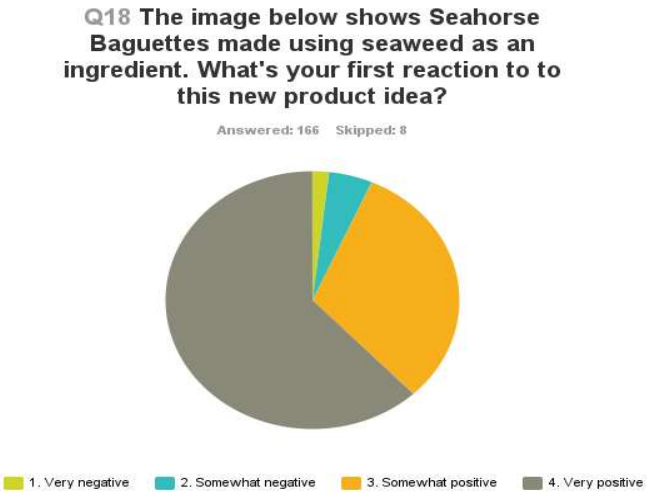


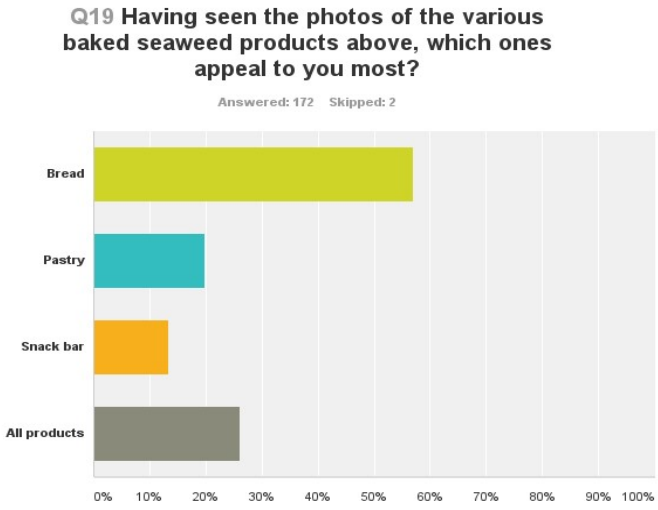
Figure 11: Summary, seahorse baguettes made with seaweed

Source: Developed for this study

The results of Q.18 reveal a less negative view of seahorse baguette made with seaweed. Negative sentiment fell to 6.63% for the seahorse baguette, compared to 11.18% for flapjacks, 7.93% for soda bread, 7.22% for the Danish and 1.77% for the baguette. There is a clear indication, that bread products are more favourable than other baked goods made with seaweed.

4.20 Summary, seaweed goods liked the most

- The baked goods that appealed to the respondents most were as follows: bread – 56.98%; all products – 26.16%; pastry – 19.77%; snack bars were rated lowest, at 13.37%.



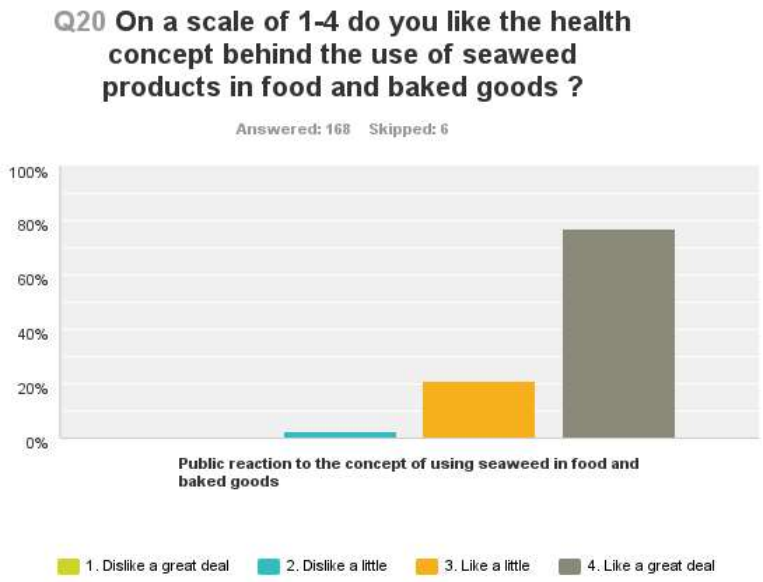
Graph 8: Summary, most preferred products

Source: Developed for this study

The results of Q.19 correlated with the actual sales tends found by the researcher in retail sales trials over a six-month period (October, 2014 to March, 2015) (refer to Appendix G). Bread products reaped, by far, the greatest interest amongst consumers.

4.21 Summary, using seaweed in foodstuffs and baked goods

- 76.79% of respondents liked the concept a great deal, while 20.83% liked the idea a little, and 2.38% of respondents disliked it a little.



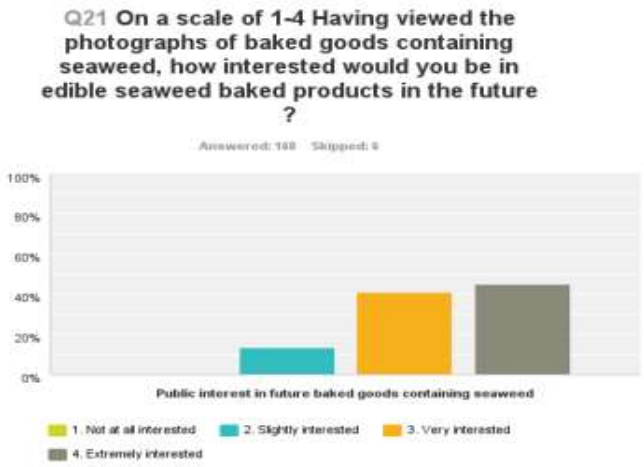
Graph 9: Summary, concept of using seaweed in food and baked goods

Source: Developed for this study.

The great majority of the respondents were open to, and indeed liked, the concept a great deal. The findings are indicative that consumers are very aware of health, and are willing to choose new products which will improve and maintain their health. This trend is reflected in the Bord Bia (2014b) survey data compiled by Insight (refer to Appendix D).

4.22 Summary, seaweed-baked goods in the future

- The respondents were asked to express the level of their future interest in seaweed-baked goods. The results are as follows: extremely interested – 46.24%; very interested – 41.07%; slightly interested – 13.69%. No participant was recorded as being not at all interested.



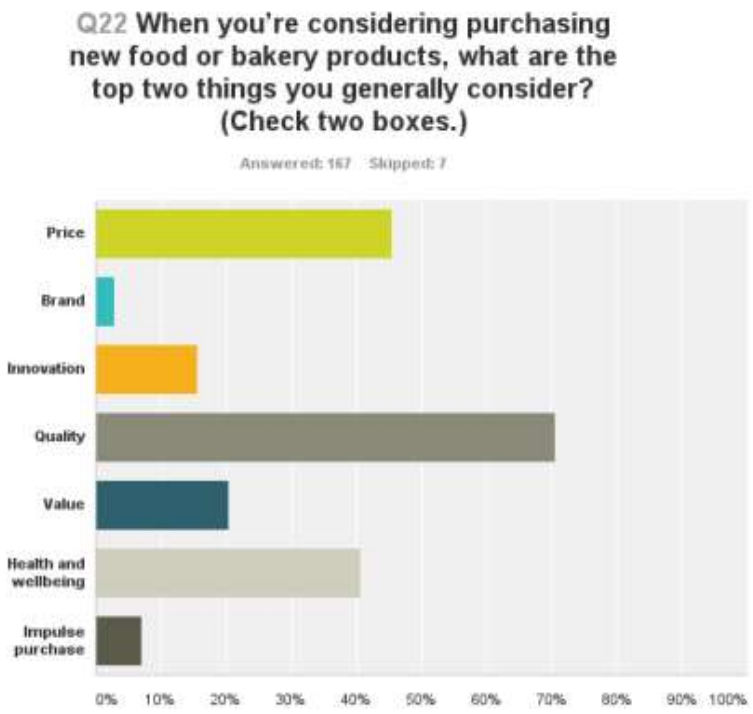
Graph 10: Summary, future interest in baked goods containing seaweed

Source: Developed for study

A great majority of the respondents expressed a desire for the availability of seaweed-baked goods. They were open to, and liked, the concept a great deal. The findings are indicative that consumers are very aware of health, and desire new products which will improve and maintain their health. As no commercial recipes or methods for seaweed bread were discovered during the secondary research, there is no comparison to be drawn in this case.

4.23 Summary, top two important factors when purchasing baked goods

- Respondents' top two factors when purchasing a new food or bakery goods were as follows: quality – 70.66%; pricing – 45.51%; health and wellbeing – 40.72%; value – 20.36%; innovation – 15.57%; impulse purchase – 7.19%; and brand – 2.99%.



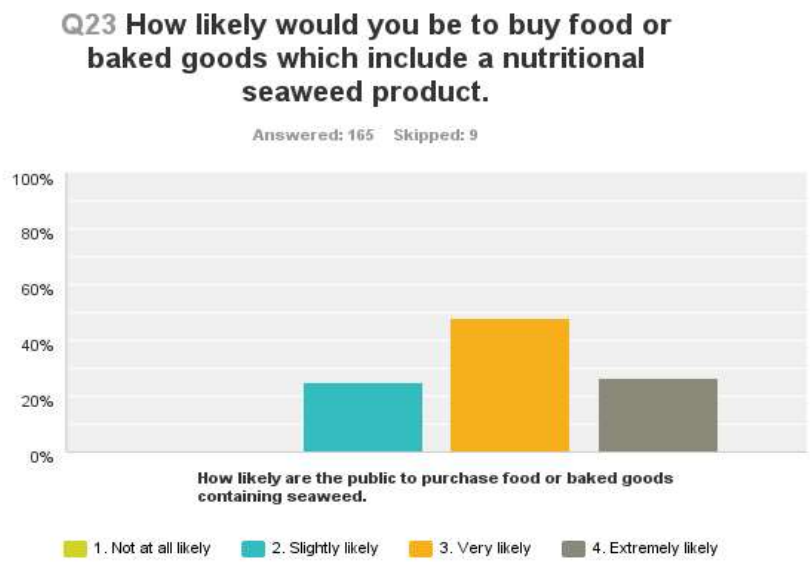
Graph 11: Summary, considerations when purchasing food or bakery product

Source: Developed for this study

Quality, price, along with health and wellbeing, were the top three factors which respondents indicated in this study as affecting the decision to purchase baked goods. This is a very positive result, as consumers desire high quality, affordability and a health aspect to the food or baked goods purchased. These findings are similar to those documented in the Bord Bia 2014 bakery sector survey (Bord Bia 2014a, p.6) (refer to Appendix D).

4.24 Summary, whether respondents would purchase a seaweed-baked product

- Respondents were asked how likely they would be to purchase baked goods that contain a nutritional seaweed product. “Very likely” was selected by 47.88%, while “extremely likely” was indicated by 26.67%, and “slightly likely” by 24.85%.



Graph 12: Summary, respondents' attitudes to purchasing nutritional seaweed products

Source: Developed for this study

A two-thirds majority of those surveyed expressed that they would be interested in purchasing a seaweed-based food. The survey appears to have also served as an educational exercise, and has stimulated interest among the respondents in seaweed use in baked goods and other foods.

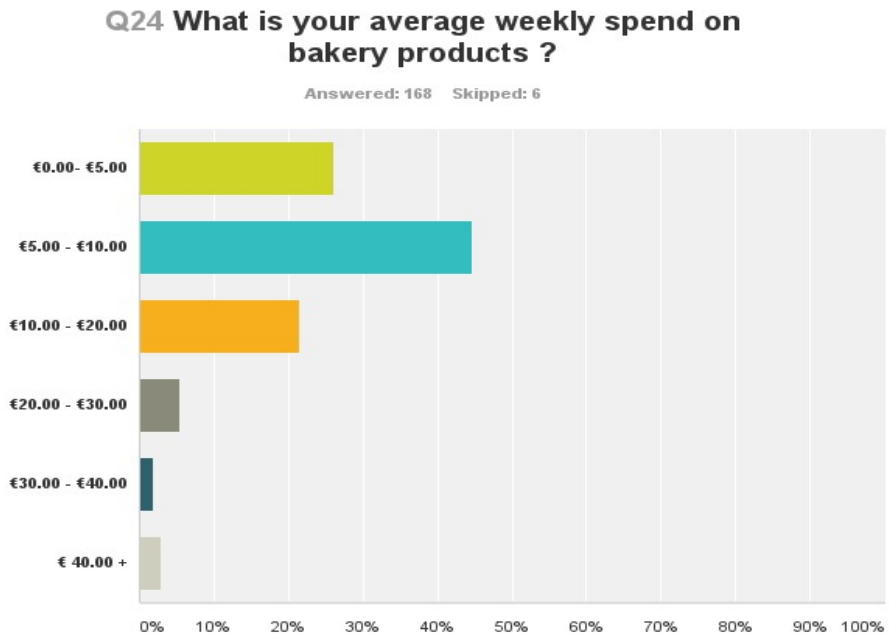
4.25 Summary, weekly expenditure on bakery products

- The respondents were asked to list their weekly spend on baked goods. The figure below explains that the average weekly spread of consumer spend ranged from €5.00 to €40.00 +

• €0.00- €5.00	• 26.2%
• €5.00 - €10.00	• 44.6%
• €10.00 - €20.00	• 21.4%
• €20.00 - €30.00	• 5.4%
• €30.00 - €40.00	• 1.8%
• € 40.00 +	• 3.0%

Table 5: Summary, the average weekly spend on bakery products

Source: Developed for this study



Graph 13: Summary, weekly spend

Source: Developed for this study

The weekly spend on bakery goods was very low among the group included in this survey. According to Bord Bia (2014a, pp.35-36) (Appendix D), freshly baked and natural ingredients are key factors which will drive consumers to pay more for baked goods. Of those surveyed, 34% indicated that they would pay more for baked goods containing ingredients with a specific health benefit. Bord Bia (2014b) states that Irish consumers spend €393 million annually on baked goods (refer to Table 12). The population of Ireland was measured as 4.6 million by the Central Statistics Office (Central Statistics Office 2014) in 2014. This

equates to the weekly spend per person in Ireland averaging at €1.64 per person, per week. Considering that the average Irish family consists of two adults and two children (Central Statistics Office 2014), the weekly spend on bakery products by consumers would be up to €6.56. This data is reflected by 44.6 % of the respondents.

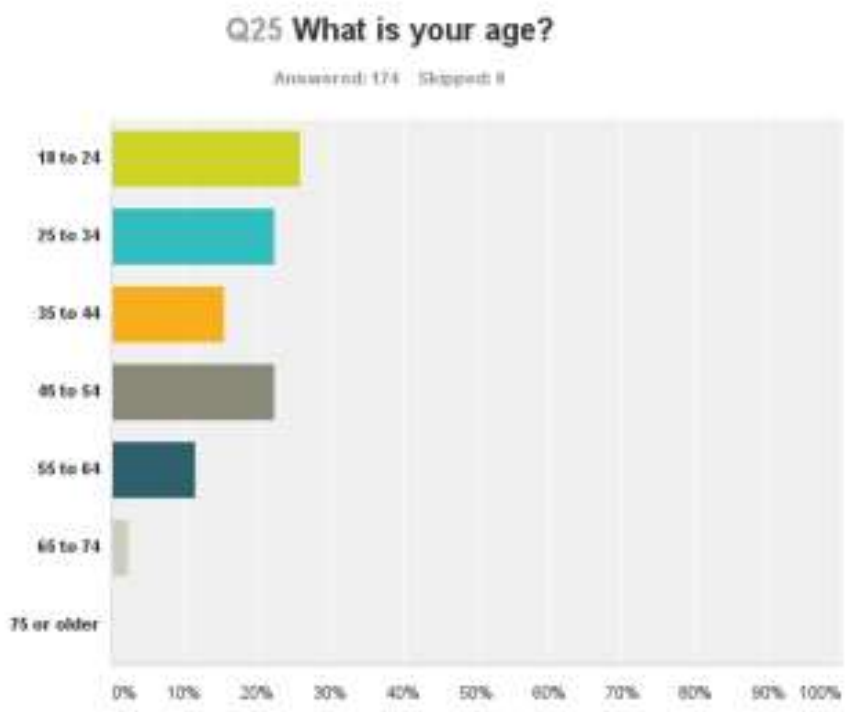
4.26 Summary, age profile

- The age profile of the respondents was measured from age 18 to age 75 or older. The data is set out in varying age profiles segmented initially in groups of five years, with the remainder in groups of nine years.

Table 6: Summary, age segmentation %

18 to 24	25.9%
25 to 34	22.4%
35 to 44	15.5%
45 to 54	22.4%
55 to 64	11.5%
65 to 74	2.3%
75 or older	0.0%

Source: Developed for this study



18 to 24	25.9%
25 to 34	22.4%
35 to 44	15.5%
45 to 54	22.4%
55 to 64	11.5%
65 to 74	2.3%
75 or older	0.0%

Graph 14: Bar chart age profile

Source: Developed for this study

The age profile measured by the survey indicates a wide spread, and a mostly even mix, which can be considered a pleasing result, as the respondents were from a variety of age groups, with differing tastes, backgrounds, requirements and purchasing power.

4.27 The main findings from the primary research

The main findings from the online questionnaire demonstrate that there is already public awareness of the health benefits of seaweed and its use in food. The findings illustrate that the public are open to trying new choices of foods (Bord Bia 2014a; Bord Bia 2014b) which contain a nutritional benefit for them. The participants were mostly Irish people residing in

Connaught and Leinster. There were also a significant percentage of respondents who lived abroad (22.08%). Over 78% of respondents considered the health benefit when purchasing nutritional food products. The largest group of respondents were aged 18 to 24 (29.5%), and were mainly female (63.79 %). The majority were very likely to buy food with nutritional seaweed content. While the greatest spend from a group on baked goods was relatively low (€5.00-€10.00), the survey results demonstrated that the respondents were open to purchasing seaweed products as highly nutritional foods with health benefits. The data has been referenced back to the findings in Chapter 2 and compared to statistical data from the CSO (2014) and Bord Bia (2014b).

It is clear from the findings that 167 respondents surveyed made at least one healthy food choice option daily. This provides a strong indication that the younger generation – aged 18-44 years old – 63.8% were concerned about their health and wellbeing. There was also an understanding among over 90% of respondents that a healthy diet combined with exercise was of primary importance. The majority of the respondents (71.6%) had previously consumed, and were familiar with, a seaweed product. This was further supported by the fact that only 27.4% of respondents were unaware of the potential health benefits of consuming seaweed. Scientific findings that were presented in the survey met with very favourable reactions, with only 1.78% of those viewing the scientific findings negatively. The survey results concerning the respondents' reactions to images of baked goods containing seaweed were all very positive. Bread products containing seaweed were the most prevalent group, in this regard, scoring 56.98%, while snack bars scored 13.37%. There was a large majority of respondents who would purchase the seaweed-baked goods in future, and who liked the concept of seaweed-baked goods. Chef Shaya highlights that "we eat with our eyes" (Shaya, 2013). The findings overwhelmingly demonstrate that, if food is presented in an attractive manner, there will be interest in it, and it will be consumed.

4.28 Chapter conclusion

Chapter Four presented the primary research findings. Following a brief outline of the methodology, this chapter addressed the results of the online survey detailed in Chapter Three. The results from the study were mostly quantitative in nature. The survey was

distributed to more than 8,000 potential respondents. The response after 10 days was 174, which the researcher's supervisor deemed to be sufficient for an undergraduate dissertation. The data was subsequently collected, examined and summarised under its various headings. When compared to the secondary data from Chapter Two, and the various appendices, it supported many of the questionnaire results, and granted the researcher greater insight into his area of investigation. The research also highlighted that this particular area of study was very new, that there is currently a scarcity of data in this area, with much more exploration to be completed.

Chapter Five: Discussion

5.1 Introduction

This study set out to investigate the beneficial use of seaweed in bread and the broader food industry. This chapter is aimed at providing the reader with a conclusion to the study, and will focus on the main findings reaped from the work. The results of this dissertation are drawn together from the primary research and the findings in Chapter Four, in addition to the extensive secondary research detailed in Chapter Two, and the questionnaire and actual sales figures of seaweed products from Chapter Four. The significant outcomes from the collected data will be identified and discussed. This chapter will endeavour to draw, interpret and provide recommendations concerning how seaweed may be better promoted as a mainstream food in Western culture. Seaweed has many scientifically proven health benefits; this has long been known and appreciated in Asian culture. By educating Western consumers regarding its value in their diet, greater consumption of it may be possible by promoting and marketing it in a more positive manner. The study raises many more questions regarding the topic, and recommends aspects that should be considered in any future study.

5.2 Aims and objectives

- The aim of this dissertation was to investigate the beneficial use of seaweed in bread and the broader food industry.

The objectives of the study were as follows:

- To discuss the evolution, use and consumption of seaweed;
- To compare and contrast literature related to the use of seaweed as a source of food;
- To investigate the health benefits of the regular consumption, and general use, of seaweed in a variety of foodstuffs;
- To conduct quantitative research drawing from data resources within the researcher's means of time and finance. The findings discovered during the course of this investigation (from the online survey, the literature review and from the

analysis of sales of products developed for the study) were designed to complement the primary and secondary research.

- To offer recommendations concerning how to increase the use of seaweed in food.

5.3 Key findings

The main conclusions from the primary data resulted from the study of the secondary data, presented in the literature review. Having consulted the literature, it was clear that there were few seaweed products available for consumption in Ireland, other than packaged dillisk, carrageen moss and nori. Five new products were developed by the author to better gauge the interest in seaweed products amongst consumers. The products were developed and photographed, and the data was used to assist in structuring the online questionnaire. The questions were drafted and distributed using Facebook and email. The feedback from the survey indicated the following main points:

- The target market was mostly Irish, female, young and interested in their health and wellbeing;
- Most make healthy eating choices for a minimum of one meal per day;
- Greater than 50% surveyed lived in a coastal area, and claimed that this influenced their decisions to consume seaweed;
- The majority of respondents (71.60%) had eaten a seaweed product prior to the survey;
- Most were aware of the health and nutritional benefits that seaweed provided;
- They valued the health benefit of a nutritional product as more significant than its price.
- They recognised that a healthy diet combined with exercise was highly significant;
- 72.6% of respondents were already aware of the many nutritional benefits of seaweed prior to participating in the survey;
- They were most interested in the fact that bread containing seaweed had certain health benefits, in particular dietary-related findings;
- Respondents reacted positively to various seaweed-baked goods, and indicated that they would be interested in purchasing them if available;

- Following on from the survey, it was found that 74.55% indicated that they would be very likely or extremely likely to purchase baked goods containing seaweed products.
- While the weekly spend on baked goods was relatively small (€5.00 to €10.00 per week), the majority of respondents in the survey were very positive about their desire to purchase and consume nutritional foods.

Pioneering studies by Brownlee (2010) and Jensen (2011), referred to earlier in Chapter Two, indicate that the trials into the uses of alginates to combat weight gain through lower calorific intake have paved the way for further research. Their collective studies indicate that alginate consumption may help to reduce obesity, by preventing fats from being absorbed by the body, which is crucial for better collective health for all. While there appears to be an initial positive reaction to the survey, seaweed is not among the mainstream foods consumed in Ireland, as compared to its consumption levels in Asia. The practice of baking with added seaweed nutrient and alginate drinks is very much in a state of infancy, so it will be some time before products containing seaweed become prominent in any levels of volume production. Promising outcomes from the survey (refer to Sections 4.15 to 4.19) suggest that, when presented attractively, seaweed products can be desirable to consumers. This aspect of the survey has been confirmed by way of actual sales in the researcher's bakery store over a six-month period. The sales of seaweed products have grown in the bread sector, but have stagnated in the health bar and pastry areas, and these products have now been withdrawn. Feedback from the pictures of seaweed breads and baked goods was very positive, which offers hope for the future, especially if increased seaweed consumption can lead to the overall health of a nation. The Japanese diet, as outlined earlier in Section 1.1, has confirmed the link between greater seaweed consumption and lower rates of cancer, heart disease and obesity. Bord Bia's (Bord Bia 2014a) market research has also confirmed that consumers are prepared to pay for, and are interested in, fortified bread which contains added nutritional content. The research has highlighted that seaweed, in its various forms, is already used in a wide range of food applications, such as soups, salads, pasta, sushi, breads, health bars, yogurts, gelling agents and gluten-free products. The challenge ahead relates to increasing the consumption of seaweed in the Western diet. This can be achieved by everyone in the food preparation industry, from small enterprises to government bodies. The promotion of healthy foods, and fortifying the very raw materials used to make these foods such as flour fortified with

seaweed, is achievable. National health promotion incentives provided by bodies such as Bord Bia and BIM could be further promoted on a local level by local producers and restaurateurs. Ireland's coastline extends over 5,600 km (Ordinance Survey Ireland 2015); there is great future potential for a seaweed industry which could engage in greater export, as well as providing for local demand. The growth and consumption of more seaweed on this island is possible, and has the likely capacity to improve the health and wellness of all its citizens.

5.4 Conclusion

It is the opinion of this researcher that the stated aims and objectives of this study were accomplished, and significant levels of understanding of the research question were realised. In Section 2.7 of the study, the research indicated that the food industry was well-placed to cater for the growing requirement of healthy food choices. The World Health Organization (WHO 2014) makes several recommendations by which the industry can play a significant role in promoting a healthy diet and reducing obesity:

- reducing the fat, sugar and salt content of processed foods;
- ensuring that healthy and nutritious choices are available and affordable for all consumers;
- practising responsible marketing, especially when aimed at children and teenagers;
- ensuring the availability of healthy food choices and supporting regular physical activity in the workplace.

It was also found that at least 38,417 serious birth defects were prevented in one year due to flour being fortified worldwide between 2012 and 2014 with folic acid (Food Fortification Initiative 2014) (refer to Section 2.7). Seaweed may, in the future, be incorporated into the food chain as a mainstream foodstuff that is consumed daily in some form or other. This study has highlighted the many benefits that seaweed can offer from a nutritional point of view (refer to Sections 2.7 and 2.9). The survey results presented have underlined that, with correct marketing and creativity, the food industry has the means to present seaweed foods in

a positive and desirable light (refer to Sections 4.15 to 4.21). This is critical to the success of marketing seaweed in the future, as emphasised in Section 5.5.

Grain fortification programmes (refer to Sections 2.7 and 2.8) involving the WHO (2009) have had great success in combating hunger and disease in the past. Their success has underpinned a new sickness – obesity (refer to Section 2.11), caused by the over-consumption of processed foods in the developed and developing world. Section 2.11 also discussed how seaweed alginates have, in scientific tests, demonstrated the ability to prevent fat from being absorbed into the body. The possibilities of this are enormous, considering that seaweed is a natural product which can be harvested and dried, and is not perishable in this state. Section 2.5 explored the health aspects and the fact that seaweed contains most vital trace elements needed for our very survival. With correct marketing and the scientific data to support its argument, the WHO is well-positioned to begin a new chapter. Instead of battling malnutrition, the WHO could well be engaged in the fight against human obesity for the future.

5.5 Limitations

While the research has achieved its stated aims, it was subject to certain limitations. Interviews were not conducted due to constraints of time and finance. This may have proven to be useful had it been feasible. It was deemed to be of minor importance in this particular study, as such interviews would only have gained the views of one or two participants at a time, while the online survey reached 174 within a short space of time. Having completed the work, going forward, it would be most beneficial to interview a seaweed scientist and document his/her views. It would also have been advantageous to visit a seaweed processing factory, in order to grant the author a greater understanding of the process involved. Nevertheless, despite these limitations, it is reasonable to contend that the research process was of a high quality, and that it accurately examined the subject matter appropriately. While clinical human trials on the effects of consuming alginates are still in their infancy, bringing new seaweed foodstuffs to market will require much new product development. Making these foods appetizing, desirable and mainstream in the future will prove most challenging and rewarding of all.

5.6 A final word

During the course of the literature review, the researcher discovered a particularly pertinent statement from Myslabodski (cited in Fisheries and Aquaculture Department 2003). It was felt fitting that Myslabodski should provide the final word in this paper. He explains that, “In the English language, we have done ourselves a disservice calling it ‘seaweed’: weeds are something we do not want, seaweed implies something negative about the product. When trying to convince others to eat it, ‘sea plants’ or ‘sea vegetables’ may be more appropriate words to describe it” (Fisheries and Aquaculture Department 2003).

Works Cited

Food and Health Innovation Service, 2013. *Sea Vegtables for Health,* Aberdeen: University of Aberdeen.

Adams, R., 2007. *Foundations of Health and Social Care.* s.l.:Palgrave McMillan.

Allen, D. and Hatfield, G., 2004. Medicinal Plants in Folk Tradition. *An Ethnobotany of Britain & Ireland,* 29(4), p. 1021.

American Cancer Society, 2008. *Find Support & Treatment » Treatments and Side Effects » Complementary and Alternative Medicine » Diet and Nutrition » Sea Vegetables.* [Online] Available at: http://www.cancer.org/treatment/treatmentsandsideeffects/complementaryandalternativemedicine/dietandnutrition/sea-vegetables
[Accessed 18 March 2015].

American Heart Association, 2014. *Overweight in Children.* [Online] Available at: http://www.heart.org/HEARTORG/GettingHealthy/HealthierKids/ChildhoodObesity/Overweight-in-Children_UCM_304054_Article.jsp
[Accessed 26 OCTOBER 2014].

Babbie, E. R., 2010. *The Practice of Social Research.* 12th ed. Belmont, CA: Wadsworth Cengage.

Bird, F., 2013. *The Forager's Kitchen.* s.l.:CICO Books.

Bliss, A., 1985. Ultraviolet radiation shapes seaweed communities. *Reviews in Enviornmental Science and Biotechnology,* Volume 5, pp. 141-166.

Bord Bia , 2014b. *Indusrty manufacturers insight.* [Online] Available at: http://www.bordbia.ie/industry/manufacturers/insight/publications/bbreports/Documents/Bakery%20Infographic.pdf
[Accessed 4 March 2015].

Bord Bia, 2014a. *Bakery Research.* [Online] Available at: http://www.bordbia.ie/industry/manufacturers/insight/publications/bbreports/Documents/Consumer%20Bakery%20Research.pdf
[Accessed 2 March 2015].

Brownlee, D. I., 2010. *news.bbc.co.uk.* [Online] Available at: http://news.bbc.co.uk/2/hi/uk_news/england/tyne/8579472.stm
[Accessed 1 October 2014].

Brownlee, I., Fairclough, A., Hall, A. and Paxman, J., 2012. *Seaweed :ecology, nutrient composition and medicinal uses. Marine Biology : Earth Sciences in.* Hauppauge, (New York): Nova Science Publishers.

Bruso, J., 2014. *What are side effects of eating seaweed.* [Online] Available at: http://www.livestrong.com/article/470501-what-are-side-effects-of-eating-seaweed/
[Accessed 13 December 2014].

Bryman, A. and Bell, E., 2011. *Business Research Methods.* 3rd ed. New York: Oxford University Press.

Butt, M. S. et al., 2001. Effect of Different Gums on the Quality and Shelf Life of Bread. *International Journal of Agriculture & Biology,* 10 September, 3(4), pp. 482-483.

Central Statistics Office, 2014. *Central Statistics Office Population and Migration Estimates 2014.* [Online] Available at: http://www.cso.ie
[Accessed 22 March 2015].

Centres for Disease Control and Prevention, 2008. *Morbidity and Mortality Weekly Report,* Atlanta: Centres for Disease Control and Prevention.

Collén, J. et al., 2014. Advances in Botanical Research Sea Plants. In: N. Bourgougnon, ed. *Sea Plants.* London: Elsevier, pp. 56,57,79.

Combet, E. et al., 2014. Low-level seaweed supplementation improves iodine status in iodine-insufficient women. *British Journal of Nutrition,* 9 July, 112(5), pp. 753-761.

Cone, M., 2012. *Radioactive iodine from Fukushima found in California kelp.* [Online] Available at: http://www.scientificamerican.com/article/radioactive-iodine-from-from-fukushima-found-in-california-kelp/
[Accessed 13 December 2014].

Cooper, D. S., 1998. *Business Research Methods.* 6th ed. s.l.:Irwin / McGrath Hill.

Culliney, K., 2014. *Red seaweed bread promising for heart health.* [Online] Available at: http://www.bakeryandsnacks.com/R-D/Red-seaweed-bread-promising-for-heart-health-Study
[Accessed 24 February 2015].

Denscombe, M., 2014. *The Good Research Guide: For Small-scale Social Research Projects.* 5th ed. s.l.:McGraw-Hill Education (UK).

Denzin, N. & Lincon, Y. eds., 2004. *Handbook of Qualitative Research.* Thousand Oaks(CA): Sage.

DiCamillo, K., 2014. *Exploring Umami through seaweed.* [Online] Available at: http://www.mnn.com/food/healthy-eating/stories/exploring-umami-through-seaweed
[Accessed 16 February 2015].

Diener, E. and Crandall, R., 1978. Ethics in social and behavioral research. *University of Chicago Press.*

Drum, R., 2015. *Sea Vegetables for Food and Medicine.* [Online] Available at: http://www.ryandrum.com/seaxpan1.html
[Accessed 7 April 2015].

Fisheries and Aquaculture Department, 2003. *A guide to the seaweed industry.* [Online] Available at: http://www.fao.org/docrep/006/y4765e/y4765e0b.htm
[Accessed 2 March 2015].

Fitzgerald, C. et al., 2014. Increasing the health benefits of bread: Assessment of the physical and sensory qualities of bread formulated using a renin inhibitory Palmaria palmate protein hydrolysate. *Journal of Food Science and Technology,* May, Volume 56, pp. Pages 398-405.

Food Fortification Initiative, 2014. *Food Fortification Initiative.* [Online] Available at: http://www.ffinetwork.org/about/index.html
[Accessed 14 December 2014].

Food Marketing Institute, 2008. *Food Marketing Institute,* Arlington: Food Marketing Institute.

Food Timeline. Org, 2015. *foodbreads.html#breadhistory.* [Online] Available at: http://www.foodtimeline.org/foodbreads.html#breadhistory
[Accessed 25 February 2015].

FSAI, 2010. *Consumption of Hijiki Seaweed.* [Online] Available at: https://www.fsai.ie/faq/hijiki_seaweed.html [Accessed 16 December 2014].

Gibbons, C., 2008. *Seashore.* London: Dorling Kindersley.

Goddard, W. and Melville.S., 2001. *Research Methodology an Iintroduction.* 2nd ed. s.l.:Juta & Co.Ltd.

Guiry, M., 2014. *The Seaweed Site: Information on marine algae.* [Online] Available at: http://www.seaweed.ie [Accessed 26 November 2014].

Guiry, M., 2015b. *Medicinal Uses.* [Online] Available at: http://www.seaweed.ie/uses_general/medicinaluses.php [Accessed 31 March 2015].

Guiry, M., 2015c. *Seaweed uses and utilization.* [Online] Available at: http://www.seaweed.ie/uses_general/index.php [Accessed 17 March 17].

Guiry, M., 2015d. *Use of seaweed as food in Ireland.* [Online] Available at: http://www.seaweed.ie/uses_ireland/irishseaweedfood.php [Accessed 17 March 2014].

Guiry, M. D., 2015a. *Seaweed as Human Food.* [Online] Available at: http://www.seaweed.ie/uses_general/humanfood.php [Accessed 28 February 2015].

Gusman, J., 2003. *Every Day Cooking with Sea Greens.* s.l.:Harper Collins.

Haynes, B. R., 2006 . Forming research questions. *Canadian Journal of Surgery,* Sep, 53(4), p. 278–281.

Hopkins Medicine, 2010. *John Hopkins Medicine.* [Online] Available at: http://www.hopkinsmedicine.org/hmn/w10/feature2.cfm [Accessed 25 February 2015].

Houghton, D. et al., 2013. *Treating overweight/obesity using alginate enriched bread.* Birmingham, 37th Congress of IUPS.

Indergaard, M., 1983. The Aquatic Resource. In: *Biomass Utilization.* s.l.:Plenum Publishing Corporation, pp. 137 - 167.

International Living Magazine, 2014. *The World's Healthiest Places To Live In 2014.* [Online]

Available at: http://internationalliving.com/2014/08/the-worlds-healthiest-places-to-live/ [Accessed 2 March 2015].

Jensen, M. G., 2011. *Extra weight loss from dietary fibres extracted from seaweed.* [Online] Available at: http://news.ku.dk/all_news/2011/2010.12/extra_weightloss_from_seaweed/ [Accessed 28 February 2015].

Kirk, J. and Miller, M. L., 1986. *Reliability and validity in qualitive research.* London: Sage.

Kraan, S., 2010. *How Seaweed is used in Ireland.* [Online] Available at: http://www.heritagecouncil.ie/fileadmin/user_upload/Publications/Marine/Seaweed_Poster_2010.pdf
[Accessed 02 March 2015].

Kraan, S., 2012. Algal Polysaccharides, Novel Applications and Outlook. *INTECH,* pp. 489-518.

Last, J., 2001. *A dictionary of epidemiology.* 6th ed. New York: Oxford University Press.

LeCompte, M. D. and Goetz, J. P., 1982. Problems of Reliability and Validity in Ethnographic Research.. *Review of Educational Research,* 51(1), pp. 31-60.

Leviticus, n.d. *Food Quotes section.* [Online] Available at: http://www.foodreference.com/html/q-staff-of-life.html [Accessed 13 December 2014].

Lyons, B., 2014. *Seaweed Bread Debuts in Midleton Farmers Market.* [Online] Available at: http://www.corkbilly.com/2014/12/seaweed-bread-debuts-in-midleton.html?spref=fb
[Accessed 6 April 2015].

Maberly, G. F., Bagrinsky, J. and Parvanta, C. C., 1995. *Forging partnerships among industry, government, and academic institutions for food fortification.* [Online] Available at: http://archive.unu.edu/unupress/food/V192e/ch06.htm [Accessed 25 February 2015].

Marine Institute of Ireland, 2006. *OAR Marine Institute.* [Online] Available at: http://hdl.handle.net/10793/70 [Accessed 28 December 2014].

Mc Kenna, S., 2013. *Extreme Greens.* Cork: Estragon Press.

McConnell, K. E., Corbin, C. B., Corbin, D. E. & Farrar, T., 2014. *Health for life.* Champaign(IL): Human Kenetics.

Morrissey, J., Kraan, S. and Guiry, M. D., 2001. *A Guide to Commercially Important Seaweeds on the Irish Coast.* Dublin: Bord Iascaigh Mhara / Irish Fisheries Board.

Morrissey, K., O' Donoghue, C. and Hynes, S., 2011. *Quantifying the value of multi-sectoral marinecommercial activity in Ireland,* Dublin: BIM.

Mouritsen, O. G., 2013. *Seaweeds: Edible Available and Sustainable.* s.l.:University of Chicago Press.

Netalgae.eu, 2012. Seaweed Industry in Europe Netalgae. *The Norwegisn Seaweed Industry,* 31 October.

Neuman, W. L., 2003. *Social Research Methods: Qualititative and Quantitative Approaches.* 5th ed. Boston: Allyn and Bacon.

Ní Fhlatharta, B., 2014. Smart Cookies. *The Connaught Tribune*, 31 October, p. 25.

Northern Ireland Executive, 2012. *Obesity Cuts Life Expectancy by Nine Years.* [Online] Available at: http://www.northernireland.gov.uk/news-dhssps-08032012-obesity-cuts-life [Accessed 20 March 2015].

NSW Ministry of Health, 2010. *Warning to Pregnant and Breastfeeding Women: Seaweed Soup,* Sydney: Multi Cultural Health Communication.

Ordinance Survey Ireland, 2015. *Ordinance Survey Ireland.* [Online] Available at: http://osi.ie/Education/FAQ.aspx [Accessed 7 March 2015].

Pickles, P., 2014. *Parsons Laver Bread.* [Online] Available at: www.parsonspickles.co.uk/products/laverbread [Accessed 3 December 2014].

Pomin, V. H. ed., 2012. *Seaweed: Ecology, Nutrient Composition and Medicinal Uses.* Hauppauge (NY): Nova Science Publishers.

Rae, H., 2014. *Newcastle study shows seaweeds may help obesity crisis.* [Online] Available at: http://www.thejournal.co.uk/news/north-east-news/newcastle-study-shows-seaweeds-help-6760233

[Accessed 10 November 2014].

Rehm, B. H. A. ed., 2009. *Alginates: Biology and Applications.* London: Springer.

Rosenfeld, L., 2000. Discovery and early uses of iodine. *Journal of Chemical Education ,* 1 August, 77(Rosenfeld L. Discovery and early uses of iodine. J. Chem. Educ. 2000;77:984–987. doi: 10.1021/ed077p984.), pp. 984-987.

Ryan, D., 2015. *Arbutus Bread,* Cork: s.n.

Seaweed.ie, 2015b. *Information on marine algae: Seaweed as Human Food.* [Online] Available at: http://www.seaweed.ie/uses_general/humanfood.php [Accessed 25 October 2014].

Seaweed.ie, 2015a. *Uses ireland irish seaweed food.* [Online] Available at: http://www.seaweed.ie/uses_ireland/irishseaweedfood.php [Accessed 23 February 2015].

Sekaran, U. & Bougie, R., 2009. *Research methods for business: A skill building approach.* 5th ed. Chichester: John Wiley and Sons, Inc..

Se-Kwon-Kim ed., 2011. *Marine Medicinal Foods: Implications and Applications, Macro and Microalgae.* 1st ed. Waltham: Academic Press.

Shaya, C., 2013. *At Your Palate.* [Online] Available at: http://www.atyourpalate.com/blog/2013/01/eating-with-your-eyes-changes-what-your-tongue-may-taste/#axzz3ThMbVsjT [Accessed 7 March 2015].

Siggins, L., 2014. *Irish news Seaweed farming potentially worth €10m a year.* [Online] Available at: http://www.irishtimes.com/news/ireland/irish-news/seaweed-farming-potentially-worth-10m-a-year-says-report-1.2005805 [Accessed 2 March 2015].

Smith, R., 2010. *Medical Editor.* [Online] Available at: http://www.telegraph.co.uk/health/healthnews/7494025/Seaweed-bread-could-help-fight-obesity-crisis-scientists.html [Accessed 1 October 2014].

Statistica, 2015. *net-sales-of-the-kellogg-company-worldwide.* [Online] Available at: http://www.statista.com/statistics/270203/net-sales-of-the-kellogg-company-worldwide/ [Accessed 11 February 2015].

Steele, S., 2013. Foreword. In: *Extreme Greens Understanding Seaweeds.* Cork: Estagron Press, p. 7.

Stein, J. R. and Borden, C. A., 1984. Causative and beneficial algae in human disease conditions: a review. *Phycologica,* 23(4), pp. 485-501.

Telegraph, 2012. *News Health.* [Online] Available at: http://www.telegraph.co.uk/news/health/9160343/Seaweed-toast-is-same-as-

half-an-hour-on-treadmill.html
[Accessed 12 November 2014].
Telegraph, 2013. *Food and drink Horsemeat scandal timeline.* [Online] Available at: http://www.telegraph.co.uk/foodanddrink/9857136/Horse-meat-scandal-timeline.html
[Accessed 17 February 2015].
University of Illinois, 2000. *Breads from around the world.* [Online] Available at: http://www.wellnessproposals.com/nutrition/cultural-food-diversity-program/breads-from-around-the-world-handout.pdf
[Accessed 20 March 2015].
Walsh, M. and Watson, L., 2010. *A Market Analysis towards the Further Development of Seaweed Aquaculture in Ireland. ,* s.l.: BIM.
Watson, R. R. and Preedy, V. R. eds., 2010. *Bioactive Foods in Promoting Health: Probiotics and Prebiotics.* s.l.:Academic Press.
Watson, W., 2011. *Marine Strategy Framework,* Dublin: BIM.
What when how, 2010. *Kelp and seaweed water science.* [Online] Available at: http://what-when-how.com/water-science/kelp-and-seaweed-water-science/
[Accessed 16 February 2015].
WHO, 2009. *Recommendations on wheat and maize flour fortification.* [Online] Available at: http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fortification/en/
[Accessed 29 October 2014].
WHO, 2010. *Childhood overweight and obesity.* [Online] Available at: http://www.who.int/dietphysicalactivity/childhood/en/
[Accessed 26 October 2014].
WHO, 2014. *Obeisity and overweight.* [Online] Available at: http://www.who.int/mediacentre/factsheets/fs311/en/
[Accessed 26 October 2014].
World Health Organization, 2014. *Iodization of salt for the prevention and control of iodine deficiency disorders.* [Online] Available at: http://apps.who.int/iris/bitstream/10665/136908/1/9789241507929_eng.pdf?ua=1
[Accessed 17 March 2015].

Yin, R., 2009. *Case study research: Design and methods.* 4th ed. Thousand Oaks(CA): Sage.

Bibliography

Allen, D (2010) *Forgotten Skills of Cooking*, Kyle Cathie Ltd, London .

Balasubramaniam, V, Mustar, S, Mustafa Khalid, N, Abd Rashed, A, Mohd Noh, M F, Wilcox, M D, Chater, P I, Brownlee, I A and Pearson, JP (2013) Inhibitory activities of three Malaysian edible seaweeds on lipase and α-amylase. *Journal of Applied Phycology*, 25(5), 1405-1412.

Brownlee, I A, Allen, A, Pearson, J P, Dettmar, P W, Havler, M E, Atherton, M R and Onsøyen, E (2005) Alginate as a source of dietary fiber. *Critical Reviews in Food Science and Nutrition*, 45, 497-510.

Brownlee I A, Seal C J, Wilcox, M, Dettmar P W, and Pearson J P (2009) Applications of Alginates in Food. In Rehm, B H A (Ed) *Alginates: Biology and applications*, Springer, Berlin.

Brownlee I A, Fairclough, A, Hall, A and Paxman, J (2012) The potential health benefits of seaweed and seaweed extract. In Pomin, Vitor H. Ed. *Seaweed: ecology, nutrient composition and medicinal uses, Marine Biology: Earth Sciences in the 21st Century*, Nova Science Publishers, Hauppauge. New York.

Booth, S (2001) *Food of Japan*, Interlink Publishing Group, Northampton .

Butt, M. S.; Anjum, F. M.; Samad, A.; Kausar, T.; and Mukhtar, M.T. (2001) Effect of different gums on the quality and shelf life of bread. *International Journal of Agriculture and Biology*, 3(4), 482-483.

Drew, K M (1949) Conchocelis-phase in the life-history of *Porphyra umbilicalis* (L.) Kütz. *Nature, London*, 166, 748-749.

FAO (2012) Seaweeds used as human food *in* A guide to the seaweed industry [Online]. Available: http://www.FAO.org [Accessed 3 March 2015].

Fitzgerald, C.; Gallagher, E.; Doran, L.; Auty, M.; Prieto, J.; Hayes, and M.Fitzgerald, C E. (2011) Heart health peptides from macroalgae and their potential use in functional foods. *Journal of Agricultural and Food Chemistry*, 59, 6829-36.

Flynn, P and Mc Kenna, S (2005) *Irish Food Fast and Modern*, Estragon Press, Durrus, Bantry .

Friedl, H, Dünnhaupt, S, Hintzen, F, Waldner, C, Parikh, S, Pearson, J P, Wilcox, M D and Bernkop-Schnürch, A (2013) Development and Evaluation of a Novel Mucus Diffusion Test System Approved by Self-Nanoemulsifying Drug Delivery Systems. *Journal of Pharmaceutical Sciences*, 102(12), 4406-4413.

Gibbons, C (2008) *Seashore*, Dorling Kindersley, London .

Hartley, D R (1954) *Food in England,* Little, Brown and Company, London.

Houghton, D, Wilcox, M D, Brownlee, I A, Chater, P, Seal, C J and Pearson, J P (2014) Method for quantifying alginate and determining release from a food vehicle in gastrointestinal digesta. *Food Chemistry*, 151, 352-357.

Indergaard, M and Minsaas, J (1991) Animal and human nutrition. In Guiry, M D and Blunden, G (Eds) *Seaweed Resources in Europe: Uses and Potential*, John Wiley & Sons, Chichester.

Kurlansky, M (2011) *Salt,* Random House, London .

Kushi, L.H.; Cunningham, J.E.; and Hebert, J.R. (2001) The macrobiotic diet in cancer. *Journal of Nutrition*, 131, 3056-64.

Lembi, C A and Waaland, J R (1988) *Algae and human affairs*, Cambridge University Press, Cambridge.

Mc Gee, H (2007) *On Food and Cooking: The Science and Lore of the Kitchen*, Simon and Schuster, New York .

McConnell, K E, Corbin, C B, Corbin, D E and Farrar, T (2014) *Health for life*, Human Kenetics, Champaign .

Meland, M and Rebours, C (2012) *Netalgae: The Norwegian Seaweed Industry Work Package 1 & 2*, November 2012, Bioforsk – Norwegian Institute for Agricultural and Environmental Research, Bodø .

Mitchell, M E and Guiry, M D (1983) Carrageen: a local habitation or a name? *J. Ethnopharmacol*, 9, 347-351.

Morrissey, J, Kraan, S and Guiry, M D (2001) *A Guide to Commercially Important Seaweeds on the Irish Coast*, Bord Iasciagh Mhara/Irish Fisheries Board, Dublin.

Oakley, J (2010) *Seashore Safaris*, Graffeg, Cardiff .

Ohno, M and Largo, D B (1998) The seaweed resources of Japan. In Critchley, A T, Ohno, M, Largo, D B and Gillespie, R D (Eds.) *Seaweed resources of the world*, Japan International Cooperation Agency, Yokosuka, Japan.

Pearson, J (2014) Treating overweight/obesity using alginate enriched bread, *The Journal*, 1st March, Available: //www.thejournal.co.uk/news/north-east-news/newcastle-study-shows-seaweeds-help-6760233 [Accessed 1 October 2014].

Rhatigan, P (2009) *Irish Seaweed Kitchen*, Booklink, Dublin .

Tseng, C K, Liu, T G, Jiang, B Y, Zhang, Y H and Wu, C Y (1963) Study on the growth and development of Haidai (*Laminaria japonica*) transplanted at the Chekiang coast. *Studia Marina Sinica*, 3, 102-118.

Tseng, C K (1981) Commercial cultivation. In *The Biology of Seaweeds*. (Lobban, C S and Wynne, M. J., editors), 680-725. Blackwell Scientific Publications, Oxford.

Tseng, C K and Chang, C F (1983) Chinese seaweeds in herbal medicine. *Proceedings of the International Seaweed Symposium*, 11, 152-154.

Tseng, C K (1984a) *Common Seaweeds of China*, Science Press, Beijing.

Tseng, C K (1984b) Physiological research in the development of the Chinese seaweed industry. *Hydrobiologia*, 116/117, 7-18.

Tseng, C K and Fei, X G (1987) Macroalgal commercialization in the Orient. *Proceedings of the International Seaweed Symposium*, 12, 167-172.

Tsuji, S (2011) *Japanese Cooking A Simple Art*, Kodansha, Tokyo.

Venugopal, V (2011) Marine polysaccharides: Food applications, C R C P r e s s , Boca Raton.

Wilcox, M D, Brownlee, I A, Richardson, J, Dettmar, P W and Pearson, J P (2014) The modulation of pancreatic lipase activity by alginates. *Food Chemistry*, 146, 479-484.

Wolfram, B (2011) *Seaweeds*, Koeltz Scient, Koenigstein .

Appendix A – SurveyMonkey response count and response percentages

1. What is your gender?		
Answer Options	**Response Percent**	**Response Count**
Female	63.8%	111
Male	36.2%	63
answered question		**174**
skipped question		**0**

2. In what country do you currently reside?		
Answer Options	**Response Percent**	**Response Count**
Ireland	72.5%	124
United Kingdom	13.5%	23
USA	9.9%	17
Other	4.7%	8
Other (please specify)		10
answered question		**171**
skipped question		**3**

3. If you live in Ireland, in what province do you currently reside?		
Answer Options	**Response Percent**	**Response Count**
Munster	4.5%	7
Leinster	50.0%	77
Ulster	3.9%	6
Connaught	20.1%	31
I do not live in Ireland	22.1%	34
Other (please specify)		3
answered question		**154**
skipped question		**20**

4. Do you live in a coastal area?		
Answer Options	**Response Percent**	**Response Count**
Yes	50.9%	86
No	49.1%	83
answered question		**169**
skipped question		**5**

5. Do you think that living in a coastal area would influence you more towards purchasing seaweed food products than if you did not?		
Answer Options	**Response Percent**	**Response Count**
Yes	53.8%	91
No	46.2%	78
answered question		**169**
skipped question		**5**

6. Do you take nutritional supplements?		
Answer Options	**Response Percent**	**Response Count**
Yes	41.0%	71
No	59.0%	102
answered question		**173**
skipped question		**1**

7. When you're considering purchasing nutritional products, what are the top two things you generally consider? (Check two boxes.)		
Answer Options	**Response Percent**	**Response Count**
Price	34.0%	55
Health Benefit	78.4%	127
Innovation	4.9%	8
Quality	30.2%	49
Value	13.6%	22
Nutritional content	36.4%	59
Other (specify)		7
answered question		**162**
skipped question		**12**

8. In a typical day, how many of your meals or snacks include healthy options choice							
Answer Options	**1**	**2**	**3**	**4**	**5 +**	**Rating Average**	**Response Count**
	30	48	49	23	17	42.54	167
answered question							**167**
skipped question							**7**

9. How important is a healthy diet combined with exercise to your lifestyle?		
Answer Options	**Response Percent**	**Response Count**
Extremely important	23.0%	40
Very important	32.8%	57
Moderately important	35.6%	62
Slightly important	6.3%	11
Not at all important	2.3%	4
answered question		**174**
skipped question		**0**

10. Have you ever consumed a product containing seaweed?		
Answer Options	**Response Percent**	**Response Count**
Yes	71.6%	121
No	28.4%	48
answered question		**169**
skipped question		**5**

11. Did you know that eating seaweed in food daily include the following benefits: - click all that you are aware of?		
Answer Options	**Response Percent**	**Response Count**
Natural Organic product with no preservatives.	57.7%	97
Provides physical and nutritional benefits.	46.4%	78
Increases energy levels and brain function.	23.2%	39
Contains Calcium, Magnesium, Iodine, Zinc, B Vitamins B12 & B13.	42.9%	72
Nutrients are bio-available and easily absorbed.	21.4%	36
Natural immune stimulant and gut flora modulator.	14.3%	24
Lowers GI index of baked products.	9.5%	16
Allows salt and sugar levels to be reduced in food and baked goods	19.0%	32
Allows for increased hydration in the baking process giving a moister crumb.	16.1%	27
Anti-staling effects which naturally extend shelf life of bread.	7.7%	13
Increases shelf life of products without having to use chemical additives.	8.3%	14
I had no prior knowledge of the nutritional value of seaweed.	27.4%	46
answered question		**168**
skipped question		**6**

12. Recent scientific findings indicate that regular daily intake of bread containing seaweed helps you feel fuller for longer and reduce your daily calorific intake. What's your first reaction to this information?		
Answer Options	**Response Percent**	**Response Count**
4. Very positive	57.2%	99
3. Somewhat positive	39.3%	68
2. Somewhat negative	3.5%	6
1. Very negative	0.0%	0
answered question		**173**
skipped question		**1**

13. Scientific findings indicate that a daily intake of bread containing seaweed, combined with regular exercise can bring about weight loss. Is your first reaction to this information: (click answer below)						
Answer Options	**1. Very negative**	**2. Somewhat negative**	**3. Somewhat positive**	**4. Very positive**	**Rating Average**	**Response Count**
	3	11	76	79	84.17	169
answered question						**169**
skipped question						**5**

14. The image below shows sourdough baguettes made using seaweed as an ingredient. What's your first reaction to this new product idea?						
Answer Options	**1. Very negative**	**2. Somewhat negative**	**3. Somewhat positive**	**4. Very positive**	**Rating Average**	**Response Count**
	1	2	56	110	90.68	169
answered question						**169**
skipped question						**5**

15. The image below shows Danish pastries made using seaweed as an ingredient. What's your first reaction to this new product idea?						
Answer Options	**1. Very negative**	**2. Somewhat negative**	**3. Somewhat positive**	**4. Very positive**	**Rating Average**	**Response Count**
	2	10	46	108	89.16	166
answered question						**166**
skipped question						**8**

16. The image below shows soda bread made using seaweed as an ingredient. What's your first reaction to this new product idea?						
Answer Options	**Very negative**	**Somewhat negative**	**Somewhat positive**	**Very positive**	**Rating Average**	**Response Count**
	2	11	61	90	86.43	164
answered question						**164**
skipped question						**10**

17. The image below shows flapjacks made using seaweed as an ingredient. What's your first reaction to this new product idea?						
Answer Options	**1. Very negative**	**2. Somewhat negative**	**3. Somewhat positive**	**4. Very positive**	**Rating Average**	**Response Count**
	2	17	59	92	85.44	170
answered question						**170**
skipped question						**4**

18. The image below shows seahorse baguettes made using seaweed as an ingredient. What's your first reaction to this new product idea?						
Answer Options	**1. Very negative**	**2. Somewhat negative**	**3. Somewhat positive**	**4. Very positive**	**Rating Average**	**Response Count**
	3	8	52	103	88.40	166
answered question						**166**
skipped question						**8**

19. Having seen the photos of the various baked seaweed products above, which ones appeal to you most?		
Answer Options	**Response Percent**	**Response Count**
Bread	57.0%	98
Pastry	19.8%	34
Snack bar	13.4%	23
All products	26.2%	45
answered question		**172**
skipped question		**2**

20. On a scale of 1-4, do you like the health concept behind the use of seaweed products in food and baked goods?						
Answer Options	**1. Dislike a great deal**	**2. Dislike a little**	**3. Like a little**	**4. Like a great deal**	**Rating Average**	**Response Count**
	0	4	35	129	93.60	168
answered question						**168**
skipped question						**6**

21. On a scale of 1-4 Having viewed the photographs of baked goods containing seaweed, how interested would you be in edible seaweed baked products in the future?						
Answer Options	**1. Not at all interested**	**2. Slightly interested**	**3. Very interested**	**4. Extremely interested**	**Rating Average**	**Response Count**
	0	23	69	76	82.89	168
answered question						**168**
skipped question						**6**

22. When you're considering purchasing new food or bakery products, what are the top two things you generally consider? (Check two boxes.)		
Answer Options	**Response Percent**	**Response Count**
Price	45.5%	76
Brand	3.0%	5
Innovation	15.6%	26
Quality	70.7%	118
Value	20.4%	34
Health and wellbeing	40.7%	68
Impulse purchase	7.2%	12
Other (specify)		9
answered question		**167**
skipped question		**7**

23. How likely would you be to buy food or baked goods which include a nutritional seaweed product?						
Answer Options	**1. Not at all likely**	**2. Slightly likely**	**3. Very likely**	**4. Extremely likely**	**Rating Average**	**Response Count**
	1	41	79	44	75.15	165
answered question						**165**
skipped question						**9**

24. What is your average weekly spend on bakery products?		
Answer Options	**Response Percent**	**Response Count**
€0.00-€5.00	26.2%	44
€5.00-€10.00	44.6%	75
€10.00-€20.00	21.4%	36
€20.00-€30.00	5.4%	9
€30.00-€40.00	1.8%	3
€ 40.00 +	3.0%	5
Other (specify)		5
answered question		**168**
skipped question		**6**

25. What is your age?		
Answer Options	**Response Percent**	**Response Count**
18 to 24	25.9%	45
25 to 34	22.4%	39
35 to 44	15.5%	27
45 to 54	22.4%	39
55 to 64	11.5%	20
65 to 74	2.3%	4
75 or older	0.0%	0
answered question		**174**
skipped question		**0**

Appendix B – Questionnaire

1. What is your gender?

- ○ Female
- ○ Male

2. In what country do you currently reside?

- ☐ Ireland
- ☐ United Kingdom
- ☐ USA
- ☐ Other

Other (please specify)

3. If you live in Ireland, in what province do you currently reside?

- ☐ Munster
- ☐ Leinster
- ☐ Ulster
- ☐ Connaught
- ☐ I do not live in Ireland

Other (please specify)

4. Do you live in a coastal area?

- ○ Yes
- ○ No

5. Do you think that living in a coastal area would influence you more towards purchasing seaweed food products than if you did not?

- ○ Yes
- ○ No

6. Do you take nutritional supplements?

- ○ Yes
- ○ No

7. When you're considering purchasing nutritional products, what are the top two things you generally consider? (Check two boxes.)

- ☐ Price
- ☐ Health Benefit
- ☐ Innovation
- ☐ Quality
- ☐ Value
- ☐ Nutritional content

Other (specify)

8. In a typical day, how many of your meals or snacks include healthy options choice?

1	2	3	4	5 +
◉	○	○	○	○

9. How important is a healthy diet combined with exercise to your lifestyle?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

10. Have you ever consumed a product containing seaweed?

- Yes
- No

11. Did you know that eating seaweed in food daily include the following benefits: - click all that you are aware of?

- Natural Organic product with no preservatives.
- Provides physical and nutritional benefits.
- Increases energy levels and brain function.
- Contains Calcium, Magnesium, Iodine, Zinc, B Vitamins B12 & B13.
- Nutrients are bio-available and easily absorbed.
- Natural immune stimulant and gut flora modulator.
- Lowers GI index of baked products.
- Allows salt and sugar levels to be reduced in food and baked goods
- Allows for increased hydration in the baking process giving a moister crumb.
- Anti-staling effects which naturally extend shelf life of bread.
- Increases shelf life of products without having to use chemical additives.
- I had no prior knowledge on the nutritional value of seaweed.

12. Recent scientific findings indicate that regular daily intake of bread containing seaweed helps you feel fuller for longer and reduces your daily calorific intake. What's your first reaction to this information?

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

13. Scientific findings indicate that a daily intake of bread containing seaweed, combined with regular exercise can bring about weight loss. Is your first reaction to this information: (click answer below?)

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

14. The image below shows sourdough baguettes made using seaweed as an ingredient. What's your first reaction to this new product idea?

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

15. The image below shows Danish pastries made using seaweed as an ingredient. What's your first reaction to this new product idea?

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

16. The image below shows soda bread made using seaweed as an ingredient. What's your first reaction to this new product idea?

Very negative	Somewhat negative	Somewhat positive	Very positive
○	○	○	○

17. The image below shows flapjacks made using seaweed as an ingredient. What's your first reaction to this new product idea?

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

18. The image below shows seahorse baguettes made using seaweed as an ingredient. What's your first reaction to this new product idea?

1. Very negative	2. Somewhat negative	3. Somewhat positive	4. Very positive
○	○	○	○

19. Having seen the photos of the various baked seaweed products above, which ones appeal to you most?

- ☐ Bread
- ☐ Pastry
- ☐ Snack bar
- ☐ All products

20. On a scale of 1-4, do you like the health concept behind the use of seaweed products in food and baked goods?

1. Dislike a great deal	2. Dislike a little	3. Like a little	4. Like a great deal
○	○	○	○

21. On a scale of 1-4, having viewed the photographs of baked goods containing seaweed, how interested would you be in edible seaweed baked products in the future?

1. Not at all interested	2. Slightly interested	3. Very interested	4. Extremely interested
○	○	○	○

22. When you're considering purchasing new food or bakery products, what are the top two things you generally consider? (Check two boxes.)

- ☐ Price
- ☐ Brand
- ☐ Innovation
- ☐ Quality
- ☐ Value
- ☐ Health and wellbeing
- ☐ Impulse purchase

Other (specify)

23. How likely would you be to buy food or baked goods which include a nutritional seaweed product?

1. Not at all likely	2. Slightly likely	3. Very likely	4. Extremely likely
○	○	○	○

24. What is your average weekly spend on bakery products?

- ☐ €0.00-€5.00
- ☐ €5.00-€10.00
- ☐ €10.00-€20.00
- ☐ €20.00-€30.00
- ☐ €30.00-€40.00
- ☐ € 40.00 +

Other (specify)

25. What is your age?

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 or older

Appendix C – Seaweeds for human consumption

Table 7: Major nutrients found in algae commonly used for human consumption

Official name	*Common name*	*Major types of nutrients*
Brown algae		
Alaria esculenta	dabberlocks, winged kelp	rich in proteins, vitamin B_3
Ascophyllum nodosum	rockweed, knotted wrack	rich in alginates (28% D.W.), in fucoidan (8% D.W.), in laminarin (7% D.W.), and in mannitol (7% D.W.); fucoxanthin, vitamin E
Durvillaea antarctica	-	rich in alginates, iodine, calcium, potassium, phosphorus, iron, vitamin A, B complex, C, D, E, and K
***Ecklonia* sp.**	-	alginates; fucoidan; eckol
Eisenia bicyclis	arame (Japan)	alginates; eisenin (tripeptide); vitamin A; iodine; calcium; iron; magnesium
Fucus serratus (and other *Fucus* species)	toothed wrack	rich in fucoidan (16% D.W.); fucoxanthin; beta-carotene, vitamin E
Himanthalia elongata	sea spaghetti, thongweed, *haricot de mer* (France)	fucoidan
Laminaria japonica (and other *Laminaria* species) *(main source of raw material for the alginate industry)*	*Saccharina japonica*, kelp, oarweed, kombu/kondu (Japan), haidai (China)	rich in alginates (32% D.W.), in laminarin (16% D.W.), in mannitol (14% D.W.), in proteins (10% D.W., incl. the amino acid taurine), in fucoidan (4% D.W.); iron; iodine; magnesium; calcium; fucoxanthin; beta-carotene;

***Macrocystis* sp.**	giant kelp, sea ivy	vitamin A, B_3, C, D, E, K rich in alginates, mannitol, and vitamin E
***Sargassum* sp.**	limu kala (Hawaii)	alginates; fucoidan; mannitol (12% D.W.); taurine
Undaria pinnatifida	wakame (Japan)	rich in alginates (34% D.W.); in laminarin (3% D.W.); fucoidan; proteins (incl. the amino acid taurine); vitamin B_2, C, E

Red algae

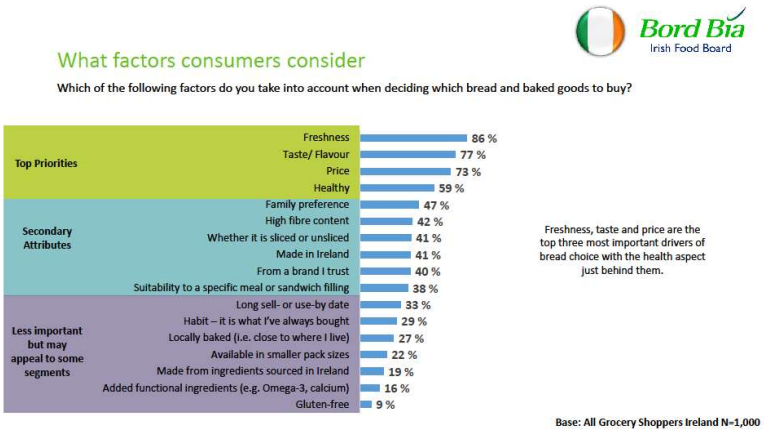
Chondrus crispus	Irish moss	rich in carrageenans (kappa and lambda) (50% D.W.), floridoside (10% D.W.), and taurine (5% D.W.); beta-carotene; vitamin B complex
Eucheuma denticulatum *(commercial crop for carrageenan; formerly Eucheuma spinosum)*	spinosum	rich in carrageenans (esp. iota); lectins
***Gelidium* sp.**	limu lo-loa (Hawaii), hai tenguaa (China)	rich in agar (30% D.W.)
***Gigartina* sp.**	-	rich in carrageenans (kappa)
***Gracilaria* sp.** *(major source of agar)*	ogo, ogonori (Japan), sea moss	rich in agar (25% D.W.); carrageenans; phycobiliproteins; lectins
Kappaphycus alvarezii (formerly *Eucheuma cottonii*)	cottonii	carrageenan (kappa) (22% D.W.)
Mastocarpus stellatus	carrageen moss	carrageenans (kappa and lambda)
Palmaria palmata	söl (Iceland), dulse	rich in floridoside (25% D.W.); iodine; carotenoids; vitamin B complex; taurine-

		rich proteins
Porphyra sp.	nori (Japan), kim (Korea), laver, slawk	rich in proteins (up to 50% D.W., *incl.* the amino acid taurine), in porphyran (up to 45% D.W.), in floridoside (up to 40% D.W.), and in chlorophyll; beta-carotene; vitamin A, B complex, C, E; potassium; magnesium; iron
Green Algae		
Caulerpa lentillifera	sea grapes, green caviar, umi-budo (Japan)	rich in iodine; phosphorus; calcium; magnesium
Codium sp.	dead man's finger	lectins
Ulva lactuca (and *Ulva intestinalis*)	sea lettuce, green laver, ansori (Japan), limu palahalaha (Hawaii)	rich in ulvan (up to 56% D.W.), fucoidan, glucuronic acid, and iron; calcium; vitamin A, B complex, and E; proteins (up to 20% D.W.; esp. lectins); chlorophyll; beta-carotene
Microalgae		
Arthrospira sp. (cyanobacterium)	spirulina	rich in phycobiliproteins (up to 70% of D.W.); chlorophyll a and b (1% D.W.), vitamin B complex, and E; proteins; linolenic acid; beta-carotene
Chlorella (green alga)	-	rich in beta-glucan; beta-carotene; astaxanthin; vitamin C; chlorophyll (3% D.W.); EPA (40% of total lipids)
Crypthecodinium cohnii (dinoflagellate)	-	high levels of PUFA (37% D.W.), esp. DHA
Dunaliella sp. (green alga)	-	rich in chlorophyll and beta-carotene
Haematococcus sp. (green alga)	-	rich in astaxanthin and chlorophyll
Porphyridium sp. (red alga)	-	rich in chlorophyll and phycobiliproteins
Shizochytrium sp. (fungus-like microalga)	-	high level of PUFA, esp. DHA
Tetraselmis sp. (green alga)	-	high level of PUFA, esp. DHA; chlorophyll; vitamin E

Source: (Food and Health Innovation Service, 2013 p. 7-10)

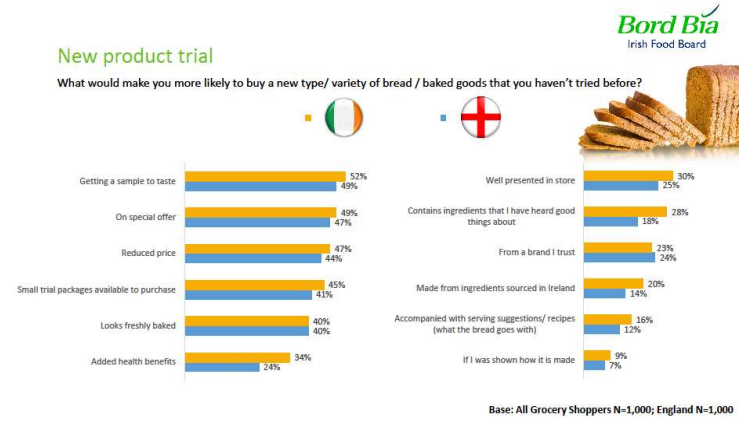
Appendix D – Bord Bia Bakery Market Surveys 2014

Table 8: What factors consumers consider when purchasing bread



Source: Bord Bia (2014a, p.7).

Table 9: New bread product/type trial choices



Source: Bord Bia (2014a, p.21).

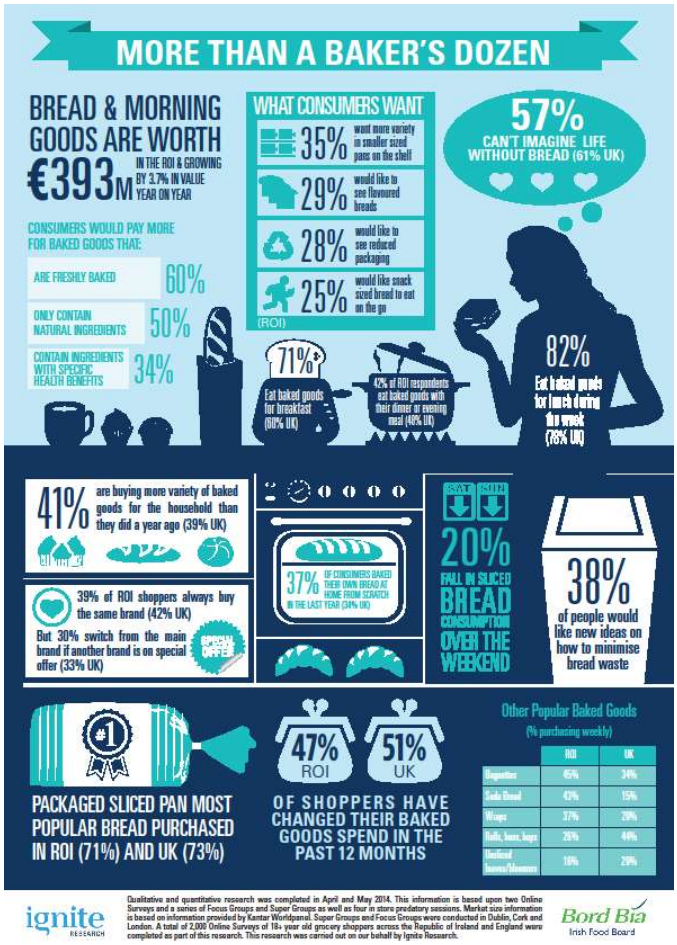


Figure 12: Bread and morning goods consumption habits Ireland and UK 2014

Source: Bord Bia 2014b

Appendix E – Sample clinical trials of seaweed in bread and beverages

Study 1 Bread trials using seaweed (2012)

Dr. Craig Rose of Sheffield Hallam University (Telegraph, 2012) has completed food and tasting trials using seaweed bread. The findings set out below are very promising and were conducted on 80 subjects.

Seaweed toast is the same as half an hour on the treadmill. Breakfasting on a slice of bread baked with ground-up seaweed could help burn more calories than half an hour on a treadmill, according to new research trials on nearly 80 healthy but overweight men showed those fed scrambled egg on seaweed enriched toast felt so full they consumed 179 calories less a day. The tests at Sheffield Hallam University are the first to involve adding the entire seaweed plant to the bread mix rather than breaking it down to extract various chemicals. The bread – served with the crusts cut off – did not include any salt at all with the seaweed acting like a total replacement.

None of the men could tell the difference between an ordinary loaf and the slices seasoned with seaweed – which has a similar taste but far lower sodium levels. As well as cutting salt intake, the seaweed also acted as a bulking agent, so the men felt fuller and less hungry. So when they were presented with as many 400 gram bowls of pasta and tomato based sauce as they could eat for lunch some drew the line after a couple of bowls.

The seaweed was sourced from the pristine waters of the Scottish Outer Hebrides where it is harvested, dried and milled at a local factory. Dr Craig Rose from The Seaweed Foundation, which supported the study, said: “It is not as salty as normal bread, but you don't notice any marine flavours and it is very acceptable. It is just like eating standard bread. It rises just the same and looks just the same. If it is white bread, you might notice a touch of green. But it would just look like basil or poppy seed which appeals to the bread companies. It's not a salty taste it is mineral because seaweed is very rich in all the minerals. It has far more minerals than any land plant. It tastes minerally and works flavour wise.”

The test panel split into groups of five was fed a 100 gram slice of normal bread for one week and the enriched bread the next. The scrambled egg was just to make the toast more palatable

without butter. Researchers from Sheffield's Centre for Food Innovation checked how much they ate and blood pressure levels. They found the men fed the seaweed bread consumed 179 fewer calories in a day, with 100 calories being significant for weight loss.

Dr Rose added: "This is the first time that this has looked at using the whole seaweed as a food. All that has happened is it has been dried and milled. Other works have looked at extracting chemicals from the seaweed and using them. So this study is paramount in using whole seaweed to provide all the benefits. There is also on-going research showing it increases the shelf life of the product. The seaweed acts a bulking agent in the stomach giving a feeling of fullness. It has sodium in low levels but far less than salt. It is also natural, sustainable, and organic and adds nutrition. So unlike most bulking agents it is not just filling something out for the sake of cheapness."

Lecturer in Nutrition Anna Hall, who led the study, said: "I tried the bread and really liked it. It does look a bit different to normal wholemeal. The seaweed is fine granules, so the bread looks a bit speckled, but it tastes very nice." Health food enthusiasts are familiar with seaweed broken down into elements such as kelp. "But we wanted to use the whole seaweed because it is rich in fibre as well as minerals and what we have achieved is a very welcome addition to the research around seaweed and health." Previous research has looked at using seaweed as a salt substitute with pasta. As well as using it in bread the university is also investigating applying the principle to a range of meat products including sausages, she added

Source: Sheffield Hallam University (Telegraph, 2012).

Study 2 **Extra weight loss from dietary fibres extracted from seaweed** (December 2011)

DIET a new research project conducted at the Faculty of Life Sciences (LIFE), University of Copenhagen, shows that dietary fibres from brown algae boost the sensation of satiety, thereby making people eat less and lose more weight.

Palm seaweed

Previous studies have shown that a fibre-rich diet makes it easier to maintain weight, and now a new PhD project documents that dietary fibres from brown algae, the so-called alginates, are excellent at creating an 'artificial feeling of fullness' in the stomach: "Over a three-year period, we have studied the effect of taking different alginate doses. We are able to demonstrate that the healthy subjects who took alginates and were also allowed to eat as much as they wanted felt less hungry and ate less than the subjects not drinking fibre drinks with alginates," says PhD student Morten Georg Jensen, who arrived at the findings with his colleagues.

Gel fills up the stomach

The 12-week study included 96 overweight men and women. 48 subjects drank a specially designed drink with alginates three times daily before each main course as a supplement to an energy-reduced diet. The other 48 subjects drank a placebo drink without alginates.

Greater weight loss with alginates

The 80 subjects who completed the study achieved a far larger weight loss with alginate treatment than those drinking a similar drink without alginates. On average, the subjects in the seaweed fibre drink group lost 1.7 kg more than those in the placebo group. According to the researchers, this weight loss is primarily due to a decrease in body fat percentage:" A probable explanation of the weight loss is that the alginates form a gel in the stomach which strengthens the gastrointestinal satiety signals to the brain because the gel takes up space in the stomach. The overweight subjects thus ate less than usual," says PhD student Morten Georg Jensen.

Counterweight to junk food

"The growing obesity epidemic requires research and the development of new dietary measures to counter the easy 24/7 access to enormous quantities of energy-rich food: Eating more than you burn results in a body energy imbalance, which may lead to weight gain in the long term. It is therefore crucial that new dietary measures improve appetite control and limit our food intake," says Morten Georg Jensen.The researchers hope that the research findings may pave the way for new treatment options for the overweight. In collaboration with the biotech company S-biotek, the researchers have developed the special fibre drink with alginates which the subjects drank. No such fibre drink is as yet available on the market.

Primarily palm seaweed

Seaweed covers a wide range of marine macroalgae which can be classified into three groups: brown algae (Phaephycecae), green algae (Chlorophyta) and red algae (Rhodophyta). The researchers have studied fibres from brown algae, primarily palm seaweed.

Source: (University of Copenhagen, 2011)

Study 3 Treating overweight/obesity using alginate enriched bread (2013)

D. Houghton, M. Wilcox, I. Brownlee, C. Seal, J. Pearson.

Background and Objectives:

Obesity is a rapidly growing medical issue worldwide, and is fast becoming one of the leading causes of mortality. Data from our laboratory have demonstrated that alginates have the ability to inhibit pancreatic lipase activity in-vitro, and may therefore reduce the fat absorbed in the diet [1-3]. This project has developed a bread vehicle designed by Greggs PLC that incorporates alginate and may be used in foods that people are already consuming in a "health by stealth" manner in the battle against obesity. In an acceptability study with 40 participants there were no adverse side effects with either bread, and participants preferred the alginate bread compared to the control bread. The purpose of the present study was to assess the ability of alginate enriched bread to inhibit fat digestion in-vitro and in-vivo.

Method:

Control bread (CB) and alginate enriched bread (AB) were used in the current study. In-vivo: data presented is preliminary data from a double blind crossover study conducted using ileostomy patients (n=13). Participants consumed a calorific set meal the night before and were then fasted for 12h. Upon arrival participants consumed either 105g CB or AB as toast which included 20g of butter. Blood samples were taken at baseline, immediately post eating and then every 30 minutes for 5 hours, and placed on ice until analysis. Free glycerol and total triglycerides was measured in plasma to assess fat digestion. In-vitro: three fat substrates (Trioctanoate, Trioleate and Tributyrate) were digested in an open model gut system developed within this laboratory, which replicates digestion in the mouth, stomach and small intestines. 500µl of each substrate was added alone or with 5.2g AB or CB (n=9) at 0 minutes. A 1ml sample was then taken at 180 minutes for each sample. Free glycerol was measured to assess fat digestion. A t-test was used to compare CB and AB with normal substrate digestion in the model gut, and to compare total triglycerides in plasma between CB and AB at various time points in ileostomy patients. Data presented as mean ± standard error of the mean (SEM).

Results:

Preliminary data from ileostomy plasma samples indicated a reduction in the total triglycerides in the plasma ranging from 9-34% from 0-5h compared with the control bread, with a significant difference at 210 minutes ($p>.05$). In the model gut at 180 minutes there was a significant reduction in fat digestion of 47.7% (1.2), 32.5% (2.4) and 51.1% (1.3) for trioctanoate ($p>.05$), tributyrate ($p>.05$) and trioleate ($p>.05$) respectively.

Conclusion: This study has the potential to provide evidence that normal foods supplemented with alginate can be used to treat obesity/overweight and could be utilised by the food industry. Further recruitment is required to acquire a larger group of ileostomy patients and to analyse the ileum effluent fluid to determine levels of undigested fat. Where applicable, experiments conform with Society ethical requirements.

Source: (Houghton, et al., 2013)

Appendix F – NORI Bake Pro product background

NORI Bake Pro

The information contained below is confidential and commercially sensitive. The reproduction of parts of this document within this thesis has been kindly permitted by Mr. James Cunningham and Dr. Stefan Kraan of Connemara Food Ventures. Otherwise, the reproduction or distribution of this material, or any part of this paper is not allowed without the explicit written consent of Connemara Food Ventures Ltd. As NORI is a natural product, values may vary from those listed (refer to Tables 10 and 11).

Table 10: Nutritional data for NORI Bake Pro

Minerals & trace elements	
Iodine	300 ppm
Copper	9.2 ppm
Fluoride	50 ppm
Molybdenum	48 ppb
Selenium	403 ppb
Iron	3427 ppm
Manganese	250 ppm
Cobalt	20 ppm
Chromium	2.5 ppm
Zinc	18 ppm
Borium	15 ppm
Chloride	4.40%
Calcium	3.50%
Potassium	3.30%
Sodium	2.50%
Nitrogen	1.60%
Sulphur	1.50%
Magnesium	1.50%
Silicon	0.16%
Phosphorus	0.15%

Vitamins	
Vitamin B1 Thiamine	4.5 ppm
Vitamin B2 (Riboflavin)	5 ppm
Vitamin B3 Niacin	50 ppm
Vitamin B5 Pantothenic acid	1.7 ppm
Vitamin B6 Pyridoxine	3 ppm
Vitamin B7 (Biotin)	0.10 ppm
Vitamin B8 Inositol	0.12 ppm
Vitamin B9 (Folic acid)	1.5 ppm
Vitamin B12 (cobalamin)	0.8 ppm
Vitamin C	500 ppm
Vitamin A	35 µg/g
Vitamin E	20 ppm
Vitamin K	64 ppm

Amino acids	
Tryptophan (g/100g)	0.09
Aspartic acid (g/100g)	0.95
Serine (g/100g)	0.47
Glutamic acid (g/100g)	1.01
Glycine (g/100g)	0.48
Histidine (g/100g)	0.1
Arginine (g/100g)	0.49
Threonine (g/100g)	0.45
Alanine (g/100g)	0.56
Proline (g/100g)	0.4
Cysteine (g/100g)	0.18
Tyrosine (g/100g)	0.27
Valine (g/100g)	0.49
Methionine (g/100g)	0.13
Lysine (g/100g)	0.37
Iso-Leucine (g/100g)	0.41
Leucine (g/100g)	0.54
Phenylalanine (g/100g)	0.48

Source: Connemara Ventures Ltd.

Table 11: Key Nutritionals for NORI Bake Pro, per 100g

NORI Bake Key Nutritionals	
Typical values	**100g Contains**
Energy	**250kcal**
Fat	**0.5-1g**
Of which saturates	**0.0g**

Source: Connemara Ventures Ltd.

Connemara Food Ventures is a start-up company committed to developing a premier brand of luxury bioactive foods and culinary ingredients which convey wellness to a national and an international consumer base. All ingredients are sustainably sourced, natural, and organic and validated by profound scientific insight. The company harvests and selects a blend of specific seaweeds from the west of Ireland's Atlantic waters. The seaweed is dried, milled to a fine particle size and blended to create a range of foods and ingredient mixes that are designed to taste well and confer a nutritional benefit on the consumer. The unique selling points (USPs) of the NORI Bake Pro product are listed as follows:

- Natural, organic and Irish;
- Sustainably sourced: wild-harvested or hand-cultivated in Inagh Valley, Co Galway;
- The blend has been scientifically formulated to provide physical and nutritional benefits;
- This is a proprietary formula developed over two years, and owned by Connemara Food Ventures;
- The blend is drawn from each of the three major groups of red, green and brown seaweeds, selected at the optimum stage of the life cycle for maximum functionality;

- The nutritional analysis is detailed below. Particular claims in line with EU regulations can be made on the basis of iodine content, including the promotion of normal growth in children, normal energy metabolism and normal cognitive function;
- Its nutrients are bio-available, and thus are easily absorbed by consumers;
- It is a natural immune stimulant and gut flora modulator;
- Lowers the GI index of baked goods;
- Allows salt and sugar levels to be reduced in line with EU guidelines;
- Allows for increased hydration in the baking process;
- Anti-staling effects of formula extend shelf life of baked goods;
- Alginate content gives consumers the experience of feeling “fuller for longer”.

The American Institute of Medicine (The American Society for Nutritional Sciences, 2002) defines bio-active functional food as “food or food ingredients that may provide a health benefit beyond the traditional nutrients it contains”. A food is deemed bio-active if “it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to either and an improved state of health and well-being and/or reduction in risk of disease” (Watson and Preedy 2010, p.20).

Source: Connemara Ventures Ltd.

Appendix G– Test baking trials using NORI Bake Pro

Test baking results of bakery trials using NORI bake pro

Due to a lack of bakery products in the marketplace which contained seaweed, the researcher felt that, if prototype baked products were developed, photographed and presented to consumers, it would assist in measuring public interest in baked seaweed products. Following the manufacturer's guidelines NORI Bake Pro (formerly known as ARON Seaweed Powder) was used to develop five bakery products. These were as follows:

- Seaweed soda bread
- Seaweed baguette
- Seaweed flapjack
- Seaweed laminated pastry
- Seaweed sourdough

The test baking began in the researcher's facilities in Galway during September, 2014. Test baking was conducted twice weekly for 20 weeks, and the products were marketed in the researcher's retail shop. The breads were also made and presented by the researcher during international classes conducted in Italy (2014) and Russia (2015). A soda bread recipe was developed for Connemara Food Ventures Ltd. This was further developed with added wheat germ to confer sweetness to the soda bread (refer to Appendix H). Seaweed-baked goods were introduced as new product lines in the researcher's bakery shop; the bread products remain in weekly production today.

Following the manufacturer's recommendations, the following changes were made to standard recipes using the Bakers% formula:

- NORI Bake Pro was added to all test products at 3% of the flour weight;
- Hydration was increased by 12% of flour weight in sourdough and baguettes;
- Buttermilk hydration was increased by 58.5% of flour weight in soda bread;
- Hydration was increased by 12% of flour weight for pastry;
- The flapjack recipe was not changed other than the addition of 3% NORI Bake Pro;
- The baking time was marginally increased to compensate for the greater hydration levels.

All recipes, production methods and expanded recipes are provided (refer to Appendix G).

Examples of products developed for the study (refer to Figures 13-20).

Figure 13: Dough using 3% dry seaweed

Source: Developed for this study

Figure 14: Seahorse seaweed bread

Source: Developed for this study

Creator: StijnVander Donckt Belgium

The seaweed bread dough was enriched with butter and sugar to make sweet laminated pastry items and brioche, the photos display the pastry during the lamination phase and the finished pear and raspberry baskets, which are garnished with mascarpone cheese topping. (refer to Figures 15 and 16)

Figure 15: Raw pastry with seaweed

Source: Developed for this study

Figure 16: Baked pastries with seaweed

Source: Developed for this study

Figure 17: Seaweed baguette

Source: Developed for this study

Figure 18: Seaweed Flapjack

Source: Developed for this study

Figure 19: Seaweed soda bread

Source: Developed for this study

Figure 20: Seaweed sourdough bread

Source: Developed for this study

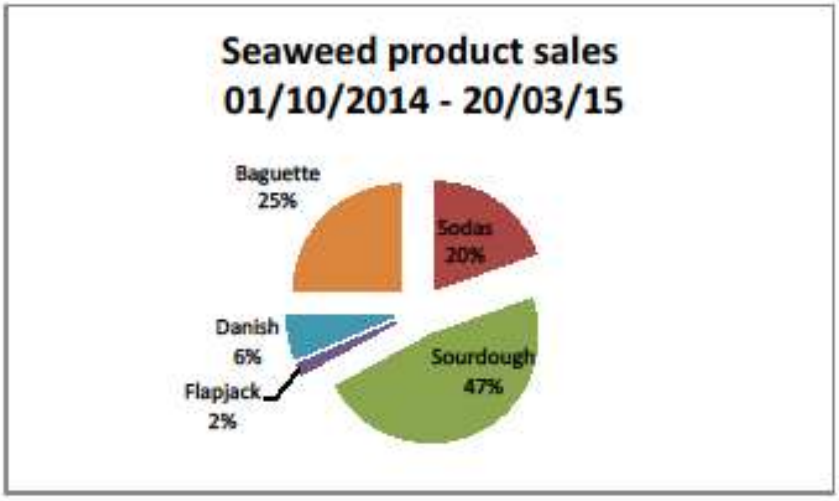
Seaweed Sales GBG October 2014 – March 2015

In order to quantify the interest and sales of seaweed products in the researcher's retail shop, Griffin's Bakery Galway Ltd. (herein referred to as "GBG"), all seaweed products were given a unique code, and a button for the products was set up on the electronic point of sale system (EPOS) in the shop. Seaweed-baked products were developed from test baking, and random taste sampling was ongoing, where the seaweed products were presented for sale, and customers had the opportunity to sample them prior to purchase. The EPOS system tracked the sales over a six-month period. The sales information was expressed as a percentage of total unit sales divided by the individual product sales in a Microsoft Excel spreadsheet (refer to Table 13). The information was imported into a spreadsheet and expressed as a percentage of total unit sales. The pie chart below represents the data gathered during the research.

Table 12: Monthly unit sales of seaweed products in GBG

Seaweed product Sales	Sodas	Sourdough	Flapjack	Danish	Baguette
Unit price	€2.65	€4.00	€2.25	€2.05	€1.95
01/10/2014 - 20/03/15	758	1842	60	249	969
Unit sales per month	117	283	9	38	149

Source: Developed for study



Graph 15: Seaweed product sales at Griffin's Bakery

Source: Developed for this study

Appendix H – Seaweed product recipes and production methods

Recipe 1: Initial test bake recipe for James Cunningham

James Cunningham' Brown Bread Re - Balanced recipe

INGREDIENTS	1 MIX	X2	X4	X6	X8	X10	X12	X14	X16	X 18	X 20	Bakers% Based on 100%
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	350
100% Wholemeal	175	350	700	1,050	1,400	1,750	2,100	2,450	2,800	3,150	3,500	50 %
Tara Pinnacle Flour Soft	175	350	700	1,050	1,400	1,750	2,100	2,450	2,800	3,150	3,500	50 %
Sugar	12.5	25.0	50.0	75.0	100.0	125.0	150.0	175.0	200.0	225.0	250.0	3.6 %
ARON Seaweed powder	6	12	24	36	48	60	72	84	96	108	120	2 %
Bread Soda	5	10	20	30	40	50	60	70	80	90	100	1 %
Baking Powder	5	10	20	30	40	50	60	70	80	90	100	1 %
Salt	4	8	16	24	32	40	48	56	64	72	80	1 %
Buttermilk	400	800	1,600	2,400	3,200	4,000	4,800	5,600	6,400	7,200	8,000	114 %
Total Weight	783	1,565	3,130	4,695	6,260	7,825	9,390	10,955	12,520	14,085	15,650	
YIELD SODAS	1	2	4	6	8	10	12	14	16	18	20	
SCALING WT in grams	782											
YIELD SCONES	30	60	90	120	150	180	210	240	270	300	330	

In August 2014, a brown soda bread was developed for James Cunningham CEO of Connemara Ventures Ltd. The recipe was formulated by the researcher using the bakers percentage method for scientific accuracy.

Recipe 2: Seaweed baguette

National Bakery School
Dublin Institute of Technology
Cathal Brugha Street,
Dublin 1, Ireland

COURSE CODE: DT418
ARTISAN BAKING

JG'S Baguette Tradition Seaweed

Processing details:

Stage	Ingredients	Gr.	Method
1 Poolish	Strong Flour T65	60	Mix together
	Yeast	1	Set aside for 15
	Water	40	hours at 19°C
	Total:	101	
2 Soak	Seaweed Extract	33	Mix water and
	Water	120	seaweed,
3 Dough	Poolish	101	Mix 2 minutes
	Strong Flour T65	1000	slow. Stop
	Water	590	machine cover. Autolysée 30 min
4 Dissolve	Water	100	Add Seaweed,
	Yeast	5	yeast and water Mix 5 minutes slow
5 Add Salt	Salt	25	Add and mix 4 minutes fast
	Total:	1974	

Details	Temp/Time	Instructions
Dough Temperature:	22°C	
Fermentation Time:	90 mins.	Stretch and Fold after 60 min- Scale after 80 min

Scaling Weight:	360g	5 Pieces Hand up into a sausage shape
Intermediate Proof:	20 to 25 mins.	Keep covered
Shape:		Mould 20 - 50 Cm long and dress if required. Place each piece on floured Coucheé cloths with seam up.
Proof Temp:	25-27°C	
Proof RH:	70%	
Final Proof Time:	70 min.	Set seam down, Single Cut, then to "S" shape Cut and dress as required. Rest 5 minutes. 20 seconds steam
Baking Temperature:	250 > 220°C	Falling to 220°C open damper after 12 min
Baking Time:	25 - 30 min.	

Further Details / Notes

Baguette with Seaweed

											Bakers%	H2O%
INGREDIENTS	1 MIX	X2	X4	X6	X8	X10	X12	X14	X16	X 18	X 20	Based on 100%
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	1,060	80.19
Starter Poolish Stage 1													
Strong Flour	60	120	240	360	480	600	720	840	960	1,080	1,200	6 %	
Yeast	1	2	4	6	8	10	12	14	16	18	20	0 %	
Water	40	80	160	240	320	400	480	560	640	720	800	4 %	
Soak stage 2													
NORI Seaweed	33	66	132	198	264	330	396	462	528	594	660	3 %	
Water	120	240	480	720	960	1,200	1,440	1,680	1,920	2,160	2,400	11.3 %	
Dough Stage 3													
Poolish	101	202	404	606	808	1,010	1,212	1,414	1,616	1,818	2,020	9.5 %	
T-65	1,000	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000	94 %	
Water	590	1,180	2,360	3,540	4,720	5,900	7,080	8,260	9,440	10,620	11,800	56 %	
Bassinage Stage 4													
Water	100	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	9 %	
Yeast	5	10	20	30	40	50	60	70	80	90	100	0.5 %	
Delayed Salt Stage 5													
Salt	25	50	100	150	200	250	300	350	400	450	500	2 %	
Total Weight	1,974	3,948	7,896	11,844	15,792	19,740	23,688	27,636	31,584	35,532	39,480		
YIELD	5	11	22	33	44	55	66	77	88	99	110		
SCALING WT in grams	360												

Source: Developed for this study

Recipe 3: Seaweed sourdough

National Bakery School
Dublin Institute of Technology
Cathal Brugha Street,
Dublin 1, Ireland

COURSE CODE: DT418
ARTISAN BAKING

Jimmy G's Seaweed Sourdough | **THE BREAD EXPERTS**

Processing details:

Stage	Ingredients	Gr.	Method
#1 Hard Poolish	Strong Flour T65	480	Mix together
	Water	320	Set aside for 15
	Yeast	8	hours at 19°C
	Total:	808	
#2 Seaweed	NORI bake pro	140	Mix and soak 10m
Soak	Water	420	Add to dough
#3 Levain Stage	Liquid Levain	200	Add Stages 1,2&3
	Wheat Sourdough Culture	200	to Dough stage 4.
#4 Dough Stage Autolyseé	Stage#1	808	Mix 5 minutes
	Stage #2	560	slow. Stop
	Stage #3	400	machine cover.
	T – 65 Flour	4000	Autolyseé 20 min
	Water	2600	
#5 Add Yeast	Water	100	Mix 5 minutes
	Yeast	50	slow
#6 Add Salt	Salt	115	Add and mix 2 minutes fast
	Total:	8633	

Details	Temp/Time	Instructions
Dough Temperature:	21°C	
Fermentation Time:	90 mins.	
		Stretch and Fold after 60 min- Scale after 20 min

Scaling Weight:	8073 g	1 Piece Hand up into a sausage shape
Intermediate Proof:	15 mins.	Keep covered
Shape:		Mould 50" Wrap tightly. Place on Couchee cloth.
Proof Temp:	25-27°C	60 Minutes Final Proof
Proof RH:	70%	
Final Proof Time:	60 min.	Stretch out to 2 Meters on setter,dust and Cut with Diagonal lines
Baking Temperature:	240 > 220°C	Falling to 210°C
Baking Time:	55 - 60 min.	

Further Details / Notes

Seaweed Sourdough Bread

INGREDIENTS	1 MIX	X2	X3	X4	X5	X6	X7	X8	X9	X 10	X 11	Bakers%	H2O%
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Based on 100%	
												4,680	77.78
Stage #1 Hard Overnight Sponge Dough												4680	
T- 65 Strong Flour	480	960	1,440	1,920	2,400	2,880	3,360	3,840	4,320	4,800	5,280	10.3 %	
Water	320	640	960	1,280	1,600	1,920	2,240	2,560	2,880	3,200	3,520	6.8 %	
Yeast	8	16	24	32	40	48	56	64	72	80	88	0.2 %	
Sponge Weight	808	1,616	2,424	3,232	4,040	4,848	5,656	6,464	7,272	8,080	8,888	17.3 %	
Stage # 2 Seaweed Soak													
Seaweed Noribake pro	140	280	420	560	700	840	980	1,120	1,260	1,400	1,540	3.0 %	
Water	420	840	1,260	1,680	2,100	2,520	2,940	3,360	3,780	4,200	4,620	9.0 %	
Soak Weight	560												
Stage # 3 Levain MixYou can use all Levain if no culture													
Liquid Levain	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	4.3 %	
Wheat Sourdough Culture	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	4.3 %	
Stage # 4 Dough Stage Autolysée													
Add stage #1	808	1,616	2,424	3,232	4,040	4,848	5,656	6,464	7,272	8,080	8,888	17.3 %	
Add stage #2	560	1,120	1,680	2,240	2,800	3,360	3,920	4,480	5,040	5,600	6,160	12.0 %	
Add stage #3	400	800	1,200	1,600	2,000	2,400	2,800	3,200	3,600	4,000	4,400	8.5 %	
T- 65 Strong Flour	4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	44,000	85.5 %	
Water	2,600	5,200	7,800	10,400	13,000	15,600	18,200	20,800	23,400	26,000	28,600	55.6 %	
Stage # 5 Add Yeast													
Water	100	200	300	400	500	600	700	800	900	1,000	1,100	2.1 %	
Yeast	50	100	150	200	250	300	350	400	450	500	550	1.1 %	
Stage # 6 Add Salt													
Salt	115	230	345	460	575	690	805	920	1,035	1,150	1,265	2.5 %	
Total Batch Weight	8,633	17,266	25,899	34,532	43,165	51,798	60,431	69,064	77,697	86,330	94,963		
YIELD	1	2	3	4	5	6	7	8	9	10	11		
Scaling wt in grams	8633												

Source: Developed for this study

Recipe 4: Seaweed brown soda bread

National Bakery School
Dublin Institute of Technology
Kevin Street
Dublin 8, Ireland

COURSE CODE: K418

PROFESSIONAL BAKING
BREAD

Jimmy G's Seaweed BROWN SODA BREAD | **THE BREAD EXPERTS**

Stage	Ingredients	Gr.	Method
1	Whole meal Fine	350	Sieve bread soda to remove any lumps. Then sieve bakers flour, salt, baking powder, bread soda together. Blend on machine with beater for 5-6 min
	Baker's flour	200	
	Wheat Germ	50	
	Salt	10	
	Baking Powder	8	
	Bread Soda	8	
	Vegetable Oil	15	
	ARON Seaweed	15	
2	Buttermilk	810	Add butter milk to dry ingredients and knead very gently to clear. Scale @ 550g
	Total:	1466	

Processing details:

Details	Temp/Time	Instructions
Dough Temperature:		Use cold buttermilk
Fermentation Time:	none	
Scaling Weight:	550g	2 pieces scale directly into 800g pan shape
Intermediate Proof:	none	
Shape:		Cut in centre with greased scraper
Proof Time:	none	
Baking Temperature:	225°C	Bake in rectangular frames
Baking Time:	55 - 60 min.	

Further Details / Notes

BROWN SODA BREAD with Seaweed

												Bakers%	H2O%
INGREDIENTS	1 MIX	X2	X4	X6	X8	X10	X12	X14	X16	X 18	X 20	Based on 100%	
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	550	147.27
100% Wholemeal	350	700	1,400	2,100	2,800	3,500	4,200	4,900	5,600	6,300	7,000	64 %	
Tara Pinnacle Flour Soft	200	400	800	1,200	1,600	2,000	2,400	2,800	3,200	3,600	4,000	36 %	
Wheat germ	50	100	200	300	400	500	600	700	800	900	1,000	9 %	
Salt	10	20	40	60	80	100	120	140	160	180	200	2 %	
Baking Powder	8	16	32	48	64	80	96	112	128	144	160	1.5 %	
Bread Soda	8	16	32	48	64	80	96	112	128	144	160	1.5 %	
Vegtable Oil	15	30	60	90	120	150	180	210	240	270	300	3 %	
ARON Seaweed Powder	15	30	60	90	120	150	180	210	240	270	300	3 %	
Buttermilk	810	1,620	3,240	4,860	6,480	8,100	9,720	11,340	12,960	14,580	16,200	147 %	
Total Weight	1,466	2,932	5,864	8,796	11,728	14,660	17,592	20,524	23,456	26,388	29,320		
YIELD SODAS	3	5	11	16	21	27	32	37	43	48	53		
SCALING WT in grams	550												
YIELD SCONES	30	60	90	120	150	180	210	240	270	300	330		
SCALING WT in grams	110												

Source: Developed for this study

Recipe 5: Seaweed Danish pastry

National Bakery School
Dublin Institute of Technology
Cathal Brugha Street,
Dublin 1, Ireland

COURSE CODE: DT418
PROFESSIONAL BAKING

Jimmy G's Seaweed Danish | **Yeasted & Laminated Pastry**

Processing details:

Stage 1	Ingredients	Gr.	Method
Dough Stage	T -55 Bakers Flour	4000	SPIRAL MIXER
	Milk	1068	4 Minutes Slow Speed
	Water	1468	2 Minutes Fast Speed
	Nori bake pro	120	Sheet out to 20mm
	Sugar	484	Cover in Plastic
	Milk Powder	104	
	NORI bake pro	120	Leave in fridge overnight to
	Malt Powder / Liquid (Non Diastatic malt)	8	ferment
	Yeast	248	
	Salt	80	
	Unsalted Butter	128	
	Total		
Stage 2	**Ingredients**	**Gr.**	**Method**
Lamination Stage Butter Addition	Hard Dry Butter 84%	2000	Pin out dough to de gas it. Place in freezer 10 min for 0 °C Add the Butter over ¾ of the dough.
	Total:	9708	

Details	Temp/Time	Instructions
Dough Temperature:	20°C	Ferment 45 min at room temp, stretch and fold, Sheet and wrap in plastic, place dough in fridge.
Bulk Fermentation Time:	12-15 Hrs	Overnight - Covered in the Fridge @ 3 - 4°C

Lamination stages:	Stage 1	Lock in the Butter, sheet to 15mm, - freezer for 30 min
	Stage 2	Make a book turn (4) layers sheet to 15mm, - freezer for 30 min
	Stage 3	Make a half turn (3) layers sheet to 15mm, - freezer for 30 min
Sheeting the Pastry:	Stage 4	Sheet pastry to 3.5 mm
Shape:		Cut using a teardrop shaped cutter. Add pear and custard fillings, Fold over the tear drop as per photo. Egg wash carefully, taking care not to egg wash the cut edges Place in Proof box. Give second egg wash after 45 Minutes
Final Proof Time:	60 - 90 min	26 - 28.6 °C 80% humidity
Baking Temperature:	185 - 188°C	

Further Details / Notes for Pain au Chocolate.

For Pain au Chocolate, the pastry is cut into rectangular strips of 180mm x 85mm.
A chocolate bar is placed at the bottom, folded in over the pastry and two more are added.
The pastry is rolled up , egg washed and placed in the proof box , same for Croissant.
They are egg washed after 45 min and baked the same as Croissants.

Jimmy G Seaweed Croissant Recipe

INGREDIENTS PY	1 MIX	X2	X4	X6	X8	X10	X12	X14	X16	X 18	X 20	Bakers% Based on 100%
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	1000
Overnight Dough Stage 1												
T - 55 French Flour	1,000	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000	100.0 %
Milk	267	534	1,068	1,602	2,136	2,670	3,204	3,738	4,272	4,806	5,340	26.7 %
Water	367	734	1,468	2,202	2,936	3,670	4,404	5,138	5,872	6,606	7,340	36.7 %
Sugar	121	242	484	726	968	1,210	1,452	1,694	1,936	2,178	2,420	12.1 %
Milk Powder	26	52	104	156	208	260	312	364	416	468	520	2.6 %
NORI bake pro	30	60	120	180	240	300	360	420	480	540	600	3.0 %
Malt Powder	2	4	8	12	16	20	24	28	32	36	40	0.2 %
Yeast	62	124	248	372	496	620	744	868	992	1,116	1,240	6.2 %
Salt	20	40	80	120	160	200	240	280	320	360	400	2.0 %
Butter	32	64	128	192	256	320	384	448	512	576	640	3.2 %
Dough Head Weight	1,927	3,854	7,708	11,562	15,416	19,270	23,124	26,978	30,832	34,686	38,540	Butter on Dough %
Lamination Dough Stage 2												
Laminating Butter	500	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	25.9 %
Total Batch Weight	2,427	4,854	9,708	14,562	19,416	24,270	29,124	33,978	38,832	43,686	48,540	
YIELD	32	65	129	194	259	324	388	453	518	582	647	
Scaling wt in grams	75											

Source: Developed for this study

Recipe 6: Seaweed flapjack

National Bakery School
Dublin Institute of Technology
Cathal Brugha Street
Dublin 1

COURSE CODE: DT 418

PROFESSIONAL BAKING
MORNING GOODS & BISCUITS

Seaweed Hazelnut Flapjacks | **THE PASTRY EXPERTS**

Processing details:

Stage	Ingredients	Grams	Method
1	Rolled Oats	240	Mix together in a large bowl
	Dry Cranberry	20	
	Hazelnuts (toast & chop)	80	
	Seaweed Nori	1.8	
	Wholemeal Flour	60	
2	Butter	120	Heat in a saucepan until melted. Pour onto dry ingredients and mix well
	Honey	40	
	Brown Sugar	120	
	Golden syrup	80	
	Total	761.8g	

Details	Temp/Time	Instructions
Scaling Weights		1. Turn mixture into a lined Swiss roll tray (9 x 11") 2. Bake and allow cooling in the tin. 3. Cut through when baked.
Baking Temperature:	Baking Temp: 180C	
Baking Time:	Baking Time: 20-25 mins	
Storage:		

Further Details / Notes
The flapjacks may be cut into squares or into bars

Seaweed Flapjacks

INGREDIENTS	1 MIX	X2	X4	X6	X8	X10	X12	X14	X16	X 18	X 20	Bakers% Based on 100%
	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	Kg / g	
												60
Rolled Oats	240	480	960	1,440	1,920	2,400	2,880	3,360	3,840	4,320	4,800	400 %
Dry Cranberry	20	40	80	120	160	200	240	280	320	360	400	33 %
Roast Chopped Hazelnuts	80	160	320	480	640	800	960	1,120	1,280	1,440	1,600	133 %
NORI Seaweed	1.8	3.6	7.2	10.8	14.4	18.0	21.6	25.2	28.8	32.4	36.0	3 %
Wholemeal Flour	60	120	240	360	480	600	720	840	960	1,080	1,200	100 %
Butter	120	240	480	720	960	1,200	1,440	1,680	1,920	2,160	2,400	200 %
Honey	40	80	160	240	320	400	480	560	640	720	800	67 %
Brown Sugar	120	240	480	720	960	1,200	1,440	1,680	1,920	2,160	2,400	200 %
Golden Syrup	80	160	320	480	640	800	960	1,120	1,280	1,440	1,600	133 %
Total Batch Weight	761.8	1,363.6	2,727.2	4,090.8	5,454.4	6,818.0	8,181.6	9,545.2	10,908.8	12,272.4	13,636.0	
YIELD	1	2	4	5	7	9	11	13	14	16	18	
Scaling wt in grams	762											

Source: Developed for this study

Appendix I – Questionnaire cover page

Name: James A. Griffin

Course: BSc (Hons) in Baking and Pastry Arts Management

I am currently an undergraduate student in my final year on the Baking and Pastry Arts Management Degree programme at Dublin Institute of Technology, Cathal Brugha Street. As part of our final year it is required of us to complete a dissertation on a subject of our choice. My dissertation is focusing on the area of the potential health benefits of seaweed in food. The following questionnaire is an investigation into the public‘s awareness of seaweed use in food and baked goods. I would be grateful if you could take a few minutes to fill out this short questionnaire with appropriate answers. It should take no more than five minutes to complete. Please answer all questions fully and honestly in order for the study to be accurate. All questionnaires will remain anonymous and confidential.

Thanking you in advance for taking the time to read and complete this questionnaire.