



Department of
**Agriculture,
Food and the Marine**

An Roinn
**Talmhaíochta,
Bia agus Mara**

Food Research **Ireland**

Meeting the needs of Ireland's
food sector to 2020 through
research and innovation

**Coordinated by the Research Division,
Department of Agriculture, Food and the Marine (DAFM)**

some of the images used on the front cover courtesy of Bord Bia.

MINISTER'S FOREWORD



I am delighted to be introducing “*Food Research Ireland – meeting the needs of Ireland’s food sector to 2020 through research and innovation*” co-ordinated by Research Division in my Department under the auspices of the industry-led Food Research Expert Advisory Committee.

Food Research Ireland will play an important role in supporting the growth targets set out in Food Harvest 2020. Since becoming Minister for Agriculture, Food and the Marine, I have wholeheartedly embraced Food Harvest 2020 and I am totally committed to ensuring it is a success. I believe that this research strategy, that aims to guide State investment in food research, will provide the scientific knowledge required to underpin new products and new processes as well as assure the safety of food we supply to our valued customers at home and abroad. We need to ensure we back up the food we are producing with sound science and robust research. This is necessary so that Ireland can be ahead of the game, a world leader, in terms of food research.

I am very impressed by the level of stakeholder consultation that has occurred in the development of *Food Research Ireland* and I believe that it is through ongoing collaboration and partnership between the industry, regulatory authorities and academia, that the research objectives contained herein will be delivered for the benefit of our nation. I am delighted that the recently finalised report of the National Research Prioritisation Exercise has recognised the agri-food sector as an opportunity area and that public research to underpin it is prioritised in the science and technology budget. Despite current budgetary constraints, I am adamant that research and innovation within the agri-food industry requires funding in order to achieve the targets set out in Food Harvest 2020.

Of course, in such difficult economic times, there will be a requirement for the industry to increase their investment in research and innovation to complement the investment by the State. I appreciate that this will put additional pressure on the sector but I believe that the full potential of the export growth opportunities can only be achieved through commitment from both the public and the private sectors. We will also need to lever more funding from the EU research funding mechanisms and optimise Irish participation in other international ventures such as Joint Programming.

Finally, I would like to thank the Food Research Expert Advisory Group for their hard work and dedication in putting together this comprehensive plan and I look forward to seeing the impact of the research investments.

A handwritten signature in black ink, which reads "Simon Coveney". The signature is fluid and cursive, written in a professional style.

Simon Coveney, TD Minister for Agriculture, Food and the Marine.

CHAIRPERSON'S FOREWORD



Food Research Ireland clearly outlines the research needs of industry, academia, consumers and regulatory authorities and represents the significant efforts of the industry-led Food Research Expert Advisory Group. This is the first time that all stakeholders within the food research and innovation system in Ireland have come together and jointly agreed their research needs to 2020. It has been a long but worthwhile journey and I would like to thank the members of the Group for all their hard work over the last 18 months in bringing this research plan to fruition. I believe that the plan will ensure that the research funded in the future through State funded research programmes will deliver outputs that will ensure growth of the food industry in line with the targets in Food Harvest 2020 and relevant priorities in the report of the National Research Prioritisation Exercise.

Dan Browne, Chairperson

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EXECUTIVE SUMMARY

The Agri-Food and Fisheries sector is critically important to the Irish economy and is our biggest indigenous industry with gross annual output approaching €22 billion, accounting for 60% of exports by indigenous firms and employing 135,000 people. There is a significant enterprise base in Ireland in the food and drink sector, with some 1,100 food companies of which over 90% are SMEs. The sector has a greater regional spread than any other manufacturing sector. The gross output value of the Irish food and drink sector is expected to almost double from €22bn to €40bn by 2030. Research and innovation has a central role to play in enabling the industry to play a strong role in Ireland's economic recovery and to also addressing the challenges faced by the sector.

Food Harvest 2020 has set a vision for the Irish agri-food and fisheries sector to **act smart, think green and achieve growth**. The Vision is one of enormous opportunity for a dynamic, consumer focused, forward looking agri-food industry that can exploit the outputs of State funded research to achieve growth. The overall goal by 2020 is to increase the value of primary output by 33%, the value-added by over 40% and exports by 42%. However, achieving this goal will require a greater partnership between industry and scientific research and will involve the prioritisation of research and development within Irish food companies. There is a need for the industry to foster a culture of entrepreneurship and innovation in order to achieve their desired growth and to increase employment within the sector.

To date, there has been substantial public investment in food research in Ireland. This investment has led to an internationally recognised cohort of highly skilled scientists within Irish research performing organisations. In addition, Irish enterprise has invested in research but at a very low level (BERD 0.65%). Food Harvest 2020 states that industry must double their investment in RDI by 2020 in order to meet the growth targets.

Food Research Ireland, facilitated by Research Division within the Department of Agriculture, Food and the Marine, has for the first time brought together, under the auspices of the industry-led Food Research Expert Advisory Group, all of the key stakeholders in Ireland's food innovation system including the Irish food industry, Enterprise Ireland, Bord Bia, Teagasc, Marine Institute, Bord Iascaigh Mhara, the higher education sector and regulatory authorities. The **Vision of Food Research Ireland** is:

To develop an integrated and focused national food¹ research and innovation plan which will guide State investment in food research, development and innovation between 2011 and 2020 to optimally enhance the competitive advantage of the food industry, support the realisation of Food Harvest 2020 targets and positively contribute to a safe, sustainable and healthy food supply for the benefit of the population.

This Vision will be achieved by delivering the following **Specific Objectives**:

1. Identification of the research needs of industry and other stakeholders so as to guide the strategic research investments in Irish research performing organisations. All investments should:
 - a) Strengthen the existing knowledge base in key strategic areas;
 - b) Increase the developmental capacity of RPO's including scale-up and semi-commercial production of the research outputs; and
 - c) Enable the Irish research community to leverage additional support for their research from EU and other International sources.
2. Ensuring that the research outputs are:
 - a) Managed appropriately and in accordance with national IP policy;
 - b) Used to underpin economic and industrial policy so as to ensure economic growth and development of the Irish food industry; and
 - c) Used to underpin improvements in national nutrition and public health policy where relevant.

¹ Including marine foods and non-alcoholic beverages

3. Developing a mechanism to monitor and assess the impact of State investments in food research so as to ensure that the investments made are cognisant of the needs of the stakeholders.

The Plan has identified 6 thematic research areas of importance, all of which are underpinned by key investment areas (see table below). Within each of the investment areas, research objectives have been clearly defined and these objectives will guide future state investments in food research and innovation in Ireland. It should be noted that investment in these key areas will be required to ensure the development of an integrated and relevant research base that can be accessed by the industry to underpin new product and process developments, enable commercialisation of research outputs and drive innovation within the sector. Sustained investment will also ensure Ireland builds on and continues to strengthen its internationally recognised research base.

The implementation of *Food Research Ireland* will be cognisant of the Report of the National Research Prioritisation Exercise, the National Recovery plan 2011 – 2014 and the availability of national and international funds for research. To ensure that it remains relevant to the needs of the stakeholders, it will require ongoing collaboration, consultation and consideration of the evolving needs of consumers, regulatory authorities, industry and academia as well as the policy needs of the State. Collaboration may involve intra- and inter-institutional partnerships, public/private partnerships or other mechanisms that are deemed appropriate.

Overall, future investments in food research must be deployed to deliver strategic value for the sector whilst at the same time recognising the needs of other stakeholders. The outputs and impacts of any investments will require monitoring and assessment regarding value for money according to agreed metrics.

Table: Six thematic research areas and the underpinning key investment areas required to ensure an integrated and relevant research base within Irish Research Performing Organisations

Thematic Research Area	Underpinning Key Investment Area
Food Product Development and Innovation	Food chemistry and formulation Sensory science Novel processing technologies Nanotechnology Encapsulation
Food Processing Technologies	Food structures Food processing technologies
Food and Health	Functional ingredients/foods and bioactives Nutrition Gut health
Food Business and Consumer Science	Consumer research
Food Chain Integrity and Sustainability	Food chain integrity Food chain sustainability
Food Safety and Quality	Food safety and quality including: <ul style="list-style-type: none"> • Microbial Hazards • Chemical contaminants • Quality, traceability and authenticity

CHAPTER ONE: INTRODUCTION



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The agri-food and fisheries sector is critically important to the Irish economy. It is Ireland's largest indigenous industry with gross annual output approaching €22 billion, it accounts for 60% of exports by indigenous firms and employs 135,000 people. There are approximately 1,100 food companies ranging from micro-enterprises to High-Potential Start-Ups (HPSUs) and from small and medium enterprises (SMEs) and large indigenous companies, to multinational Foreign Direct Investment (FDI) companies with over 90% of these being SMEs with a distinct regional distribution relative to other manufacturing industries².

The Irish food and drink industry exports 85% of agriculture output in processed form worth over €8 billion to over 170 markets worldwide. Dairy is the largest exporting food sector (€2.3bn), followed by prepared consumer foods (€1.4bn), beverages (€1.2bn), beef (€1.2bn) and other relatively smaller, but significant sectors including seafood (€350m), pork, sheepmeat, poultry, and horticulture (c. €1.35bn) (Figures Bord Bia, EI, BIM).

The food industry is Europe's largest manufacturing sector and is central to its economic development. For example, it transforms over 70% of the EU's agricultural and fisheries raw materials, generates €965 billion turnover per annum, employs 4.4million people, supports some 310,000 companies, and provides 480 million consumers daily with a wide variety of products and services across diverse countries and markets. The food supply chain connects three important sectors of the European economy – primary production, the food processing industry and the distribution sectors – that together account for more than 5% of European value-added and 7% of employment.

Importance of Agri-Food and Fisheries at a glance

Contributes gross annual output approaching €22 billion

Directly employs over 135,000 people

Provides the outlet for the produce from Ireland's 128,000 family farms

Represents 60% of manufacturing exports by indigenous firms

Domestically sources 71% of its raw materials

Source: DAFM

The world population is expected to increase to over 9 billion by 2050. There is a requirement to guarantee this growing population access to and control of safe, nutritious and culturally acceptable food and to manage the necessary balance between food demand, health and nutrition requirements and natural resources. Global systems for producing and distributing food must also be more resilient, more sustainable and more equitable. The Food and Agriculture Organisation (FAO) has estimated that we will have to produce 70% more food (net of biofuels) for an additional 2.3 billion people by 2050. The Irish agri-food and fisheries sector can play a role in meeting this target.

Consumers are becoming increasingly aware of the opportunities to improve the quality of their lives through healthy eating and of the contribution that sustainable production can make to the improvement of their overall environment. The preferences of consumers for quality, convenience, diversity and health, and their justifiable expectations of safety, ethical and sustainable food production serve to highlight the opportunities for innovation. In some areas, such as food safety, process engineering and sustainability, Europe is already a world leader. However, there are many areas where European food research performance can continue to improve.

Food Harvest 2020 has set a Vision for the Irish agri-food and fisheries sector to **act smart, think green and achieve growth**. Acting **Smart** requires a greater partnership between industry and scientific research, involves the prioritisation of research and development, and a fostering of entrepreneurship and innovation. *Food Research Ireland* brings together all stakeholders in Ireland's food innovation system to strengthen research links and to support a more focused approach to food research.

“Substantial investment in agriculture, marine and food research over the past decade has allowed Irish companies to build up wide-ranging expertise particularly in key dairy and beef sectors. This investment is a springboard for a future strategy of innovation and differentiation by Ireland’s large, dynamic and innovative food companies, many of which are significantly established in export markets.” **Food Harvest 2020**

Over the last 15 – 20 years, the Irish Government has supported the development of research capability, critical mass and capacity through various funding instruments. In 2006, the **Strategy for Science Technology and Innovation (SSTI)** was published with the aim that:

“Ireland by 2013 will be internationally renowned for the excellence of its research, and will be to the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture³.”

The implementation of the SSTI positioned Ireland to deliver many of the targets laid down in the Strategy. However, the current economic situation coupled with the recognition of the role of research and innovation in enabling Ireland's economic recovery, led the Government to engage in a National Research Prioritisation Exercise which aimed to:

- Identify 10 – 20 “opportunity areas” that should become the focus of publicly-funded R&D;
- Identify supporting fields of research of relevance to each opportunity area; and
- Develop an action plan for each opportunity area identifying specific goals for medium term and beyond and addressing barriers to achievement of these goals.

The identified opportunity areas were evaluated against four high-level criteria:

- 1. The opportunity area is associated with a large global market or markets in which Irish-based enterprises already compete or can realistically compete;**
- 2. Publicly performed R&D in Ireland is required to exploit the opportunity area and will complement private sector research and innovation in Ireland**
- 3. Ireland has built or is building (objectively measured) strengths in research disciplines relevant to the opportunity area; and**
- 4. The opportunity area represents an appropriate approach to a recognised national challenge and/or a global challenge to which Ireland should respond.**

Relevant stakeholders, including the research community and representatives from the enterprise sector were consulted. The report of the study is likely to impact on the degree to which future funding for food research is available.

DAFM has invested significantly in developing the research capacity and capability in food through Grant-in-Aid to Teagasc and Marine Institute

and, via competitive research funding programmes—the Food Institutional Research Measure (FIRM); and the NDP Marine Research Sub-programme (administered by the Marine Institute on behalf of the Department). In addition, Enterprise Ireland (EI), the Higher Education Authority (HEA), the Health Research Board (HRB), Science Foundation Ireland (SFI), and the Irish Research Council for Science, Engineering and Technology (IRCSET) have also provided funding for scientific research, infrastructure, permanent research staff and post graduate and doctorate researchers. The Food Safety Authority of Ireland (FSAI) and Safefood have also contributed to the development of knowledge in regard to food safety and nutrition.

The Irish food industry currently has a business expenditure in research and development (BERD) of approx. 0.65% of turnover. Scope exists for Ireland's food industry to increase its investment in food related research to bring it more in line with investments by the food industry in major competing nations (e.g. the UK food sector invests 2.5% of turnover in research and development)⁴. Food Harvest 2020, referencing international benchmarks, calls for a doubling of the BERD to 1.3%. To achieve this, a new and targeted approach is required to ensure that the Irish food Sector is investing in a scale of research, development and innovation (RDI) and that the state is supporting RDI capability sufficiently and in a coordinated fashion that will enable the sector meet the substantial value-added export opportunity mapped out in Food Harvest 2020.

CHAPTER TWO: CONTEXT



Images courtesy of Bord Bia

2.1 ACTING SMART, THINKING GREEN AND ACHIEVING GROWTH – THE IRISH FOOD SECTOR AND THE GLOBAL OPPORTUNITY

The future of the Irish economy has become increasingly dependent on the agri-food and fisheries sector as our leading indigenous industry. The over reliance on unsustainable sectors in recent years has confirmed that if the Irish economy is to achieve sustainable growth and prosper once again, emphasis must be refocused on improving Ireland's export performance, in which the food industry plays a key role.

Recognising the economic importance of the agri-food and fisheries industry and the issues facing it, the Government established a high-level industry group to develop a strategic vision for the long term development of the food sector in 2009. This vision, set out in Food Harvest 2020 focuses on three themes: **Act Smart, Think Green, Achieve Growth**. The Vision is based on exploiting the green potential (sustainability) of Ireland internationally; in addition to our competitive advantages in grass based production and extensive marine territories, ensuring optimum competitiveness leading to enhanced value-added growth based on research and innovation.

Food Harvest 2020 set targets (Table 2.1) for increasing the production of value added food products based on increased growth in the value of primary output in the Irish agri-food and fisheries industry such that the sector can reach a targeted increase in exports of 42 percent.

Table 2.1: Growth targets for agri-food and fisheries sector for 2020 (Source: Food Harvest 2020)

Metric	2020 Target	Increase compared to 2007 – 2009 average
Value Added Growth	€3.0 b	40%
Raw Material Supply Growth	€1.5 b	33%
Total Export Growth	€4.5 b	42%

Specific growth targets (Table 2.2) for each food sector exist for the period up to 2020. The vision of Ireland's food industry is that of being recognised as a leading exporter of quality food products; characterised by growing sales to an increasingly diverse range of markets, and a greater proportion of exports accounted for by high value-added products, providing sustainable employment throughout Ireland.

Table 2.2: Specific sectoral growth targets (Food Harvest 2020).

Sector	Target increase in volume and/or value of output (%)
Dairy	50
Beef	40
Sheep	20
Pigmeat	50
Poultry	10
Seafood	43

Achieving this vision will mean:

- Ireland's Food sector will play a significant role in economic growth with 50,000 people employed directly in the sector throughout Ireland and exports of €12 billion by 2020.
- Ireland's food processing sector, informed by consumer and market requirements, will have sufficient well-structured capacity to efficiently, sustainably and cost-effectively process the output from Ireland's primary production sectors.
- An industry which is underpinned and enabled by research and innovation, notable for the degree of collaboration between companies and research institutions, delivering innovative products in key areas of opportunity such as ingredients, health and wellness, and consumer foods.

Food Harvest 2020 points to **acting smart** and **thinking green** as the most promising ways for the sector to achieve targeted growth. The agri-food and fisheries export sector has seen a shift over the last number of years from commodities-based supply to one that is increasingly brand centred and consumer focused. The evolution of Ireland's food industry includes many significant positives that can support future growth; it operates to world-class standards in the areas of food safety and animal welfare, has built a multi-billion-euro-export industry by engaging with the diverse demands of consumers and is consistently meeting the exacting specifications of some of the world's most prestigious retailers and foodservice providers.

Notwithstanding this, Ireland's food sector operates in a challenging environment. For farmers and fishermen, the disparity between the cost of production and remuneration is a critical issue for ongoing viability. At the processor and manufacturing level, a perceived lack of scale, fierce international competition, international retail consolidation and changing consumer demands are challenges that require concerted action. However despite the challenging global environment and prolonged recession in many of our export markets, the last year has been a good one for the sector and has seen an upturn in agri-food exports which have grown by over 11% in 2010. This strong growth has continued in 2011⁵.

Whilst some of these challenges will remain up to 2020, the most compelling picture of the decade ahead is one of opportunity. In particular, the opportunity that exists for the Irish agri-food and fisheries industry to grow and prosper sustainably through the delivery of high quality, safe and naturally based produce. The Irish food, seafood, drink and horticulture industry has the potential to boost export returns and approach €10 billion in annual export revenues by the end of 2015⁶. To achieve this, Ireland must focus on the opportunity created by consumers who demand the highest quality in production and environmental standards; expect clear visibility on sustainability issues; and, crucially, are willing to pay a premium for such assurances.

The expected increase in the world's population will create a market the size of Western Europe every five years. In tandem with this, rapid economic development in Brazil, Russia, India and China (BRIC) is creating sophisticated new consumers who are demanding new and diverse food solutions. Meanwhile in the more mature EU and US markets, consumers will increasingly seek out and pay a premium for foods with clear and credible health, wellness and sustainability attributes. The opportunities for naturally produced Irish food, seafood and drink products are considerable, provided the industry remains competitive, committed to robust and best-in-class environmental protection and invests in research and development to produce innovative products for these markets.

2.2 FUTURE DRIVERS

POPULATION GROWTH

As stated previously, the global population is set to rise from 8 billion in 2030 to 9.2 billion by 2050. The vast majority of this population growth will take place in the developing world. Over the next 10 years, developing countries will account for 40-60% of global food commodity production. Meeting the future growth in world demand for food will require a 70% increase in global food production.

Food consumption patterns are changing. According to the OECD and FAO, by 2018, global meat consumption is expected to increase to over 320 million tonnes, a 20% increase compared to the base period (2006-2008 average)⁷. The recent FAO report on the state of the world's fisheries and aquaculture, indicates world consumption of fish is also growing to an average annual consumption of 17 kg per person.⁸

⁵ Food Harvest 2020 – Milestones for Success

⁶ Bord Bia. Performance and Prospects. Irish Food, Drink and Horticulture. 2010-2011

⁷ OECD-FAO Agricultural Outlook 2009-2018

⁸ World review of fisheries and aquaculture, FAO, Rome 2010

FOOD SECURITY

Food security is a complex issue facing all regions; it is linked to health, but also to sustainable economic development, environment, and trade. There are global concerns that future food needs of the world cannot be met, and that globalization may contribute to food insecurity and poverty in less developed regions. Global food scarcity and food poverty could become a major threat to the world's population within a decade. Therefore, new radical and innovative approaches to food production, distribution and, politics are required to ensure that food poverty will not be a defining feature of the world over the next 10 years. The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life” (World Health Organisation (WHO) 1996⁹). This concept stresses that food security is built on three pillars:

- Food availability: sufficient quantities of food available on a consistent basis.
- Food access: having sufficient resources to obtain appropriate foods for a nutritious diet.
- Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

A fundamental vision for 2050¹⁰ is that of a world that is able to guarantee a growing population access to and control of safe, nutritious and culturally acceptable food and to manage the necessary balance between food demand, health and nutrition requirements and natural resources. Global systems for producing and distributing food must also be more resilient, more sustainable and more equitable¹¹.

HEALTH AND WELL BEING

The world faces two contradictory major nutritional problems. Currently 600 million people are facing starvation, whilst at the same time a further

310 million people face the problem of obesity. Obesity is now a major public health issue for many of the world's industrialised nations. Changes in food supply and eating habits, combined with a dramatic fall in physical activity, have made obesity a global epidemic¹². The increased prevalence of obesity and diet related diseases in Ireland and many other countries, is recognised as a grand societal challenge. Unless this trend is reversed the epidemic will continue to have very high social and economic consequences for Ireland. It is increasingly evident that once established in the young, obesity continues in to adult life with associated health related problems, such as type II diabetes, cardiovascular disease, hypertension and a range of other diet related diseases. In 2008, across the 27 countries of the European Union, 59% of adult men and 48% of adult women were either overweight or obese. In Ireland in 2010, 28% of men and 21% of women were obese¹³.

The Vision of the Joint Programming Initiative (JPI)¹⁴ ‘A Healthy Diet for a Healthy Life’ concludes that “the increased prevalence of obesity, especially among children and low-income groups, may be indicative of a worsening trend of poor diet and low physical activity across the EU population.” The JPI also points to negative impacts on life expectancy, a reduction in the quality of life and increased health costs as a result of lifestyle-related diseases unless approaches to alleviate such consequences are adopted by the EU population. Further views of the JPI include that better diets and increased physical activity will contribute to preventing or reducing the risk of illnesses; reducing the high costs of health services; and deliver diet related health benefits, including better development of bone and brain function, better intestinal health, less micronutrient deficiencies and improved dental health.

The impact of diet on our health is undoubtedly a challenge both nationally and internationally for society and for the food industry, and will be a future driver of innovation within the food industry and in the formulation of public health policy.

⁹ <http://www.who.int/trade/glossary/story028/en/>

¹⁰ UN FAO 2009

¹¹ European Commission – Standing Committee on Agricultural research (SCAR). The 3rd SCAR Foresight Exercise Sustainable Food consumption and production in a resource-constrained world. February 2011.

¹² Source: OECD health Data 2010, Obesity and the Economics of Prevention: Fit not fat, September 2010

¹³ Results of the Food Consumption Database Survey - Food for Health Research Initiative

¹⁴ See www.healthydietforahealthylife.eu for details on the JPI.

CONSUMER TRENDS

To better predict and be more prepared to meet consumers' future needs requires companies to have a knowledge and understanding of their customers. Possessing insights to consumer trends helps companies be more outward looking, more focused on the future and can act as a catalyst for innovation. The world has changed rapidly over the past three years: trading successfully in such a volatile environment means an understanding of consumers has never been more important. To achieve sustainable growth it is important for companies to distinguish between what is just a function of today's economic crisis and what represents a fundamental shift in the way consumers will engage with the marketplace of the future.

To achieve success in today's market firms have to get the right message to the consumer regarding their value proposition. A focus on innovation and planning is critically important in helping manufacturers enhance their long term viability and success in what is an increasingly competitive marketplace. A critical challenge for all food businesses is building a genuine lasting value that is relevant for consumers and customers. Businesses must also ensure they are well placed to take advantage of future growth and in doing so bring new innovations to markets.

In supporting Ireland's food industry to maximise its innovation potential, Bord Bia identified and described six consumer lifestyles trends (Table 2.3)¹⁵. These trends come from an understanding of the macro forces facing the lives of consumers around the world such as social, technological, economic, environmental and political factors and from an understanding of the "on the ground" consumer and brand behavior that occurs in response to these drivers. They are supported by empirical evidence including a quantitative study covering 18 markets and 80% of global GDP together with on the ground views from over 40 cities in every continent of the world.

Table 2.3: Consumer lifestyle trends

Consumer Lifestyle Trend	What the trend means to the consumer?
Consumers in control	<i>"I like to pursue better value, to help maintain my lifestyle and to get the most from the money I have"</i>
Fluid lives	<i>"I want to stay in control of my busy life and make sure that I am at my best for whatever the day presents"</i>
Making the most out of life	<i>"I need to balance the stresses in my everyday life with experiences that are fun and fulfilling"</i>
Sustainable lives	<i>"I would like products that create less negative impact on the world; I want choices that make me feel good without harming my wallet"</i>
Quest for health and wellness	<i>"I want to be in control of my health and wellness, to manage or improve it through making better choices"</i>
Keeping it real	<i>"I am looking for products and brands that are real and authentic, because they have stood the test of time and remained true to their heritage; they provide me with comfort and reassurance."</i>

(Source: Bord Bia)

To benefit fully from these emerging consumer trends, the Irish food and drink industry requires access to ongoing research both domestically and internationally as well as investment in innovation to ensure it can offer the range and quality of products required by the consumer.

¹⁵ <http://www.bordbia.ie/industryservices/information/publications/bbreports/ConsumerLifestyleTrends2.aspx>

A COMPETITIVE INDUSTRY

A globally competitive Irish food industry is fundamental to being able to capture a share of the increased demand for food products. Economic development is rapid and some new consumers increasingly sophisticated. Typical of this new breed of consumers are those in the BRIC countries; whom in demanding new and diverse food solutions create new opportunities for innovative food firms. The markets for naturally produced Irish food and drink products are considerable. To capture a share of this expanding market opportunity, Ireland's food industry must remain competitive; be committed to compliance with robust and best-in-class environmental standards and enhance its ability to create high value-added products

Ireland's food industry must confront a range of challenges, such as those posed by the dynamics of sustainability, world trade liberalisation and retailer buyer power. The industry response to these challenges will influence the success of Irish food in new markets such as those driven by an increasing global population and the rapid economic development in the BRIC countries.

Ireland's Food Sector exists in a complex system of primary production and secondary processing of varied scale and degrees of fragmentation. It operates within complicated trade/income support mechanisms, government regulation and it currently faces a range of specific sectoral challenges including:

- Competitiveness
- Production quotas
- Buyer power
- Market led products and the need for innovation
- Commodities, volatility and trade liberalisation
- Sustainability and the environment
- Primary production efficiencies

With the exception of the opportunity resulting from the ending of milk quotas and a potential 50% increase in the Irish milk pool, all the above challenges are largely cross-sectoral. The multi-stakeholder nature of some of these challenges requires that a concerted effort is made by all parts of the industrial and technological support system to help companies. Research and innovation play an important role in enabling the industry to rise to these challenges and exploit the opportunities they present.

FOOD CHAIN INTEGRITY & SUSTAINABILITY

Food Harvest 2020 sets out the importance for Ireland to maintain its reputation as a food producer of high integrity and to clearly convey the key points of differentiation that can enhance Ireland's position as a supplier of high quality food products and enhance the image of Ireland as 'The Food Island'.

Due to rising energy costs, climate change, and an increased awareness by consumers of the 'carbon footprint' concept, food chain integrity and sustainability has become a significant issue for the food sector. Fossil fuel reserves will continue to decline in the next decades with a corresponding increase in demand by over 44% from 2006 to 2030¹⁶ and this will not only lead to a further increase in greenhouse gas (GHG) emissions but also higher energy prices. The Irish food and beverage sector consumed 507 kilotonnes of final energy in 2009¹⁷. This was 23% of all industrial final energy consumption in Ireland. As consumers become more conscious of the impacts on the environment of their food consumption patterns, so too the food industry recognises its need to reduce the impacts of the food supply chain on the environment by using less energy, less water, more sustainable raw materials and by reducing waste.

¹⁶ OECD (2009) The Bioeconomy to 2030: designing a policy agenda

¹⁷ Energy in Ireland 1990 – 2009. SEAI report (2010)

CHAPTER THREE: "FOOD RESEARCH IRELAND" MEETING THE NEEDS OF IRELAND'S FOOD SECTOR TO 2020 THROUGH RESEARCH AND INNOVATION



Images courtesy of Bord Bia

Achieving smart, green and sustainable growth requires a strong research capacity and critical mass in key research areas and an innovative enterprise base to exploit the outputs of the research. This is the premise upon which *Food Research Ireland* is based. *Food Research Ireland* is a Plan for meeting the needs of Ireland's food sector to 2020 through research and innovation. The Plan, developed under the auspices of the Food Research Expert Advisory (FREA) Group, is intended to guide all state investment in food research in Ireland and will cover the period 2011 – 2020. The FREA group was set up in 2007 by the then Minister for Agriculture & Food as recommended in the AgriVision 2015 Action Plan. This Group chaired by an Industry representative includes representatives from Teagasc, The Marine Institute, Bord Bia, Bord Iascaigh Mhara, Food & Drink Industry Ireland (IBEC), Food Safety Authority of Ireland, SafeFood, Enterprise Ireland, Consumer Association of Ireland, nominated representatives of the HEI's and the IoTI's and representatives of Irish food companies¹⁸. Primary agriculture and fisheries (incl. catching and aquaculture) production research is not considered in this Plan. Both are considered separately through the Agriculture Research Expert Advisory Group (AREA)¹⁹ which has considered agriculture production research issues and through Sea Change²⁰ in respect of fisheries related research issues.

The Plan considers all food research issues identified by the food processing sector as well as those identified by regulatory authorities with responsibility for food. Where research is required to address the whole food supply chain, specific recommendations have been made. It will act as a guide to future Government Department, development agency and funding agency investments in food related research activity in Irish public research organizations.

The Vision of Food Research Ireland is:

To develop an integrated and focused national food²¹ research and innovation plan which will guide State investment in food research, development and innovation between 2011 and 2020 to optimally enhance the competitive advantage of the food industry, support the realisation of Food Harvest 2020 targets and positively contribute to a safe, sustainable and healthy food supply for the benefit of the population

¹⁸ See Appendix III for list of members.

¹⁹ AREA has developed a Strategic Research Agenda (SRA) for the Agriculture Production Sector entitled "Stimulating Sustainable Agricultural Production through Research and Innovation". This SRA covers the following thematic research areas – animals, crops, sustainability and socio-economic, policy and other cross sectoral issues.

²⁰ Sea Change – A Marine Knowledge, Research and Innovation Strategy for Ireland 2007- 2013

²¹ Including marine foods and non-alcoholic beverages

This Vision will be achieved by delivering the following **Specific Objectives**:

1. Identification of the research needs of industry and other stakeholders so as to guide the strategic research investments in Irish research performing organisations (RPO's).

All investments should:

- a) Strengthen the existing knowledge base in key strategic areas;
- b) Increase the developmental capacity of RPO's including scale-up and semi-commercial production of the research outputs; and
- c) Enable the Irish research community to leverage additional support for their research from EU and other International sources.

2. Ensuring that the research outputs are:

- a) Managed appropriately and in accordance with national IP policy;
- b) Used to underpin economic and industrial policy so as to ensure economic growth and development of the Irish food industry; and
- c) Used to underpin improvements in national nutrition and public health policy where relevant.

3. Developing a mechanism to monitor and assess the impact of State investments in food research so as to ensure that the investments made are cognisant of the needs of the stakeholders.

Development of Food Research Ireland:

Research Division within DAFM co-ordinated the overall development of *Food Research Ireland* with support from the membership of FREA Group. To ensure that the Plan was reflective of industry research needs, the food industry was divided into 6 main sectors each of which developed a Strategic Research Agenda (SRA). Each sectoral group considered the following areas in the development of the SRA:

- Strategic work areas where additional basic research was required were identified;
- The current knowledge deficit was described;
- The implications of the current knowledge deficit were elucidated;
- The commercial benefit to Irish industry if the current knowledge deficit were addressed was identified; and
- The potential areas for publicly funded research projects to address in this area were outlined.

Other stakeholders were also consulted throughout the process including regulatory authorities, state agencies and academia. A Working Group²² comprising of members of the FREA group and academia progressed the Plan to completion. Figure 3.1 describes the process of developing *Food Research Ireland* – a plan for meeting the needs of the Irish food sector to 2020 through research and innovation.

²² Working Group included DAFM, EI, MI, Bord Bia, SafeFood, Teagasc, UCD, UCC,

Figure 3.1: The process employed in the development of Food Research Ireland.



Food Research Ireland is a plan for meeting the research needs of Ireland’s food industry. Delivering on the Smart objectives set out in Food Harvest 2020 will require recognition of the role that others will play in realising the innovative potential of the Irish food industry. *Food Research Ireland* is one of the mechanisms by which the ambitious targets set in Food Harvest 2020 will be realised; as indicated in Figure 3.2 – many other actors and facilitators are needed to enable the food industry to exploit the global opportunities identified in Food Harvest 2020.

Figure 3.2: Actors and facilitators involved in delivering Food Harvest 2020 targets



CHAPTER FOUR: STRATEGIC RESEARCH AREAS



Images courtesy of Bord Bia

Ireland's food industry is uniquely placed to lead economic growth in the export oriented indigenous manufacturing sector. However, this growth will only result from the development of new and innovative products, underpinned by a safe and secure food chain. The success of a National Food Research and Innovation Plan requires that the areas of research strength in Research Performing Organisations (RPO's) are strongly aligned with the research requirements of the consumer, Ireland's food industry and the national and international food regulatory agencies. Figure 4.1 beside provides an overview of the key drivers and enablers that were considered in the context of the Plan and the key role the consumer and the industry has in any research and innovation system.

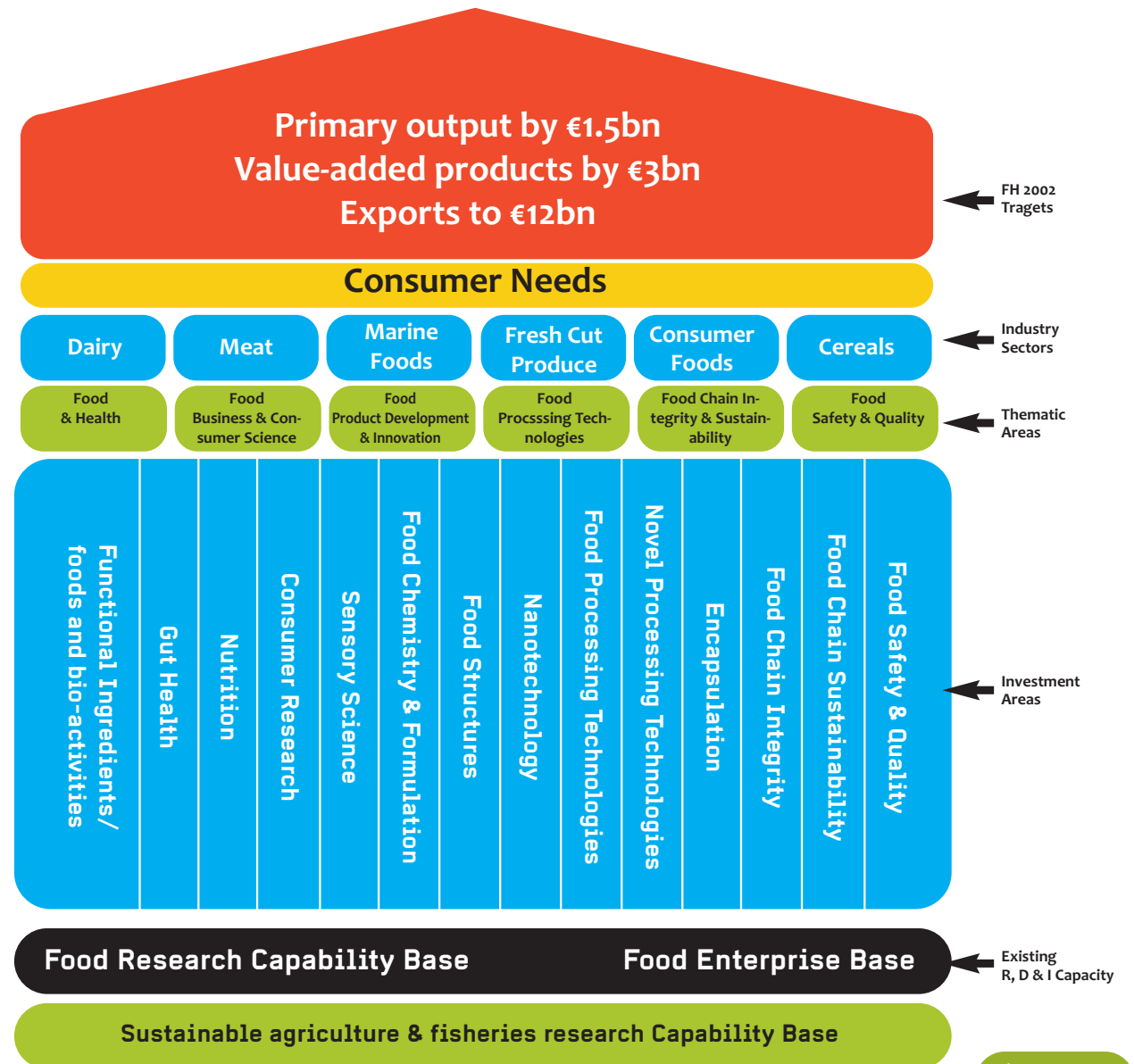


Figure 4.1:
The food innovation system.

The food innovation system is driven by the targets set in Food Harvest 2020 which have been based on consumer trends and societal challenges such as climate change, sustainability and food security.

Future food research programmes should ensure the integration of key investment areas including food chemistry, food structure, food formulation science, food processing technology, sensory science, nutritional research, consumer science and food safety and quality. Each of the investment areas presented in Figure 4.1 make an important contribution to the pipeline of new product development. Integration of the investment areas is critical as individually they will not deliver innovative food products, nor will they enhance the competitiveness of the Irish food industry or differentiate our produce in global markets²³.

There are two important points to note about the key investment areas depicted above and described in detail in this Chapter. Firstly, they are all interlinked and incorporated within the Plan; this integration must continue to be fostered if research is to be translated into tangible food products and services which in turn are driven by consumer needs. Secondly, in some areas, particularly those of nanotechnology and food bioactives, Irish research, while being globally competitive, remains relatively underdeveloped. Fostering research excellence in the areas where there exists a high level of competence and the development of competencies in new and emerging research areas, is a key component of the Plan. The Plan comprises six main research themes, all of which are linked to research strengths²⁴ within Irish research organisations. The six thematic research areas are:

- Food Product Development & Innovation
- Food Processing Technologies
- Food & Health
- Food Business & Consumer Science
- Food Chain Integrity and Sustainability
- Food Safety & Quality

Each thematic research area is aligned with the industry sectoral research agendas and consumer drivers and is underpinned by fourteen investment areas which are described in detail in Sections 4.1 to 4.6. The relationship between each research area and its underpinning key investment areas is presented in Table 4.2.

It should be noted that no attempt has been made to prioritise the overall thematic research areas, the key investment areas within each of the thematic areas, or the research objectives. Implementation of the Plan is considered in Chapter 5.

²³ Primary agriculture and fisheries (incl. catching and aquaculture) production research is not considered in this Plan. Both are considered separately through the Agriculture Research Expert Advisory Group (AREA) which has considered agriculture production research issues and through Sea Change in respect of fisheries and aquaculture related research issues. Food Research Ireland considers all research issues identified by the food

processing sector as well as those identified by regulatory authorities with responsibility for food. Where research is required to address the whole food supply chain, specific recommendations have been made.

²⁴ Further details on Irish food research infrastructure and strengths is presented in Appendix 1 of this document.

Table 4.2: Alignment of research areas to key investment areas (Main Investment Areas - Green; Supporting Investment areas - Blue)

Thematic Research Areas	Key Investment Areas													
	Consumer Research	Food Structures	Food Chemistry & Formulation	Sensory science	Food processing technologies	Novel processing technologies	Nanotechnology	Encapsulation	Functional Ingredients / foods & Bioactives	Food safety & quality	Food Chain Integrity	Food Chain Sustainability	Nutrition	Gut Health
Food Product Development & Innovation	Blue	Blue	Green	Green	Blue	Green	Green	Green	Blue	Blue			Blue	Blue
Food Processing Technologies	Blue	Green	Blue	Blue	Green	Blue	Blue	Blue		Blue			Blue	
Food & Health	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue			Green	Green
Food Business & Consumer Science	Green			Blue			Blue		Blue		Blue	Blue	Blue	
Food Chain Integrity & Sustainability	Blue									Blue	Green	Green		
Food Safety & Quality	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	

With respect to each thematic area, the *main* investment area (green) is differentiated from *supporting* investment areas (blue) in order to highlight the strategic importance of the former in sustaining the overarching thematic area. For example, in the case of the thematic area “Food & Health”, the main investment areas requiring support are functional ingredients / foods & bioactives, nutrition and gut health. Funding of these areas is deemed critical to the development of overall research capacity in food and health.

Supporting investment areas are identified as consumer research, food structures, food formulation, sensory science, novel technologies etc.

The following sections describe in detail each of the six thematic research areas, the main key investment areas and the associated research objectives. In addition, each section also presents the consumer drivers and the alignment of industry strategic research agendas to thematic areas.

4.1 FOOD PRODUCT DEVELOPMENT AND INNOVATION

Consumer Drivers: Food Innovation is critical to allow the Irish food and drinks industry better predict and prepare for consumers' future needs and wants. In today's challenging environment many companies will need to look to the future and the opportunities it may present.

Industry strategic agenda: Gains in competitiveness and opportunities for new products can result from the introduction of new processing technologies. Ireland's food sectors need the knowledge generated by research into food chemistry and formulation, novel processing technologies, which enable the formulation of foods, to support product development activities. Spanning novel approaches to packaging, shelf-life and food safety assurance and including processing techniques, this research will help Irish companies to better customise food materials to meet exacting consumer and end user requirements.

Main Investment Areas

Food chemistry & formulation
Sensory science
Novel processing technologies
Nanotechnology
Encapsulation

Supporting investment Areas

Food processing technologies
Food structures
Functional ingredients / foods & bioactives
Food safety & quality
Nutrition
Gut health
Consumer research

ALIGNMENT OF THE PROPOSED FOOD PRODUCT DEVELOPMENT & INNOVATION RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA:

The research needs of Ireland's meat, dairy, horticulture, cereals and marine sectors include a requirement to examine the extraction of bioactives from a range of natural materials. Nanoprocessing is likely to play an increasingly important role in separating, concentrating or purifying bioactives to achieve a potent, usable end product. Indeed nanocapsules to deliver bioactives via targeted delivery to the appropriate physiological site could enhance their efficacy. Nanotechnology can help to detect food contamination and can also be used to create packaging that enhances shelf life; particularly that of meat, fish and ready meals. Research to provide industry with a dedicated nanotechnology toolbox is required whilst also evaluating safety aspects.

In the context of innovation, exploiting food production waste streams can contribute to overall competitiveness. The potential exists to extract bioactive components and other materials from waste products. New technologies can help in capturing value from the by-products of meat, dairy, marine and prepared consumer foods production whilst at the same time minimising waste. An area of significant opportunity is the recovery of high-value novel compounds from food materials. Some novel technologies are known to disrupt cellular structure, thereby assisting and facilitating extraction processes. In view of the rising demand for high-value novel bioactives, there is a need for extensive research into the creation and application of new extraction processes.

Ensuring the quality and safety of our food products is essential in maintaining our competitiveness. Food safety and shelf life are areas where novel technological interventions play a key role. They can be used to reduce and control microbial contamination of products throughout the entire production process, control contamination on packaging and contact surfaces and even retain sensory and nutritional qualities.

Increasing the level and intensity of research into the development and application of novel technologies benefits all food industry sectors. Light based technologies could be used to reduce potential surface contamination during processing; new thermal technologies can enable the extraction of bioactives and improve the processability of food materials and assist in or accelerate processes such as fermentation.

New technologies and technical expertise are required to address the many challenges in food formulation. Targeting new market opportunities such as functional foods, foods for the elderly and improving the health profile of processed food, demand significant research contributions. All sectors face such challenges; the meat sector identified the need for the formulation expertise in functional foods containing meat products and to understand the influence of ingredient interactions used in the formulation of healthy meats. The dairy sector faces similar formulation challenges in respect of incorporating novel ingredients in cheese, beverages and desserts and in supporting improvements in dairy based nutritional products. The formulation of foods / functional foods with extracts from algae and other marine origin materials and the development of value added seafood products are other research areas which can only be met by new research.

A critical element to the successful commercialisation of research in this area will be the requirement to scale up innovations to industrial production. Ultimately, innovation based food research will need to be supported by realistic scale up, development and commercialisation opportunities taking into account sustainability and geographical constraints.

4.1.1 KEY INVESTMENT AREA - FOOD CHEMISTRY AND FORMULATION

Food chemistry and formulation is a core competency in food science and supports many food research related activities within the food

industry. Research on the interaction between the main nutrient components in food, i.e., proteins, fats and carbohydrate is key to unlocking new mechanisms for adding functionality and value to existing and new food products. Since this structure-function relationship in food matrices is primarily influenced by the processing parameters used in the Irish food industry; new knowledge is required on the effect of processing on functional characteristics to develop new innovative food products. It is also important to ensure that our knowledge of Irish commodity ingredients are optimised so that their functional performance is of such a distinctive nature that a sustainable competitive advantage in target markets and with strategic customers is garnered and then developed. Understanding the relationship between structure (at molecular and supra-molecular levels) and function, and the modulation of this relationship, can create a platform of knowledge focusing on the chemistry, rheology, structure and related processing technologies to benefit the food industry. The scope of this research must increase our understanding of the interaction of these nutrients that ultimately determines the functional, stability and quality attributes of the foodstuff.

Development of food chemistry underpinned by protein chemistry and nutrient interactions coupled with colloidal and other physical sciences is essential to stimulating innovative new product development within the food industry. In order to leverage science capability in relevant areas of food science abroad, it is essential that Ireland has a strong base in the physical sciences, mainly food chemistry, materials science, colloidal science and related formulation technologies including encapsulation. New technologies such as nanotechnologies are based on food chemistry, the applications of which are driven by current trends in formulation for sectors such as infant formula / medical and sports beverages and nutritional solutions for the elderly. These technologies can also play a role in the use of lipids from marine sources in food. Processed meats and meat quality are potential areas for exploitation of new formulation strategies built on strong chemistry understanding.

More in-depth research is required for development of cereal science driven by understanding starch chemistry. Starch is one of the largest commodity ingredients in the world and interaction with proteins is central to most processed food applications. The latter can have an impact on the research direction of dairy protein based ingredients along with many other ingredients from the dairy industry.

Ireland's food industry requires research that addresses the complexities of real food formulations which can result from research using model systems in some instances. There have been many advances in food formulation technology, particularly in the formulation of low salt and low fat products and in the development of formulations to deliver otherwise relatively unpalatable bioactive compounds. Further research is required to formulate foods that are healthy, pleasurable, convenient and affordable. Such research is critical to ensure the competitiveness of the Irish Food Industry in a global market.

In the future, new product innovation will be driven by the development of new flavours and textures in food and/or development of food components which can be exported as Smart ingredients for export elsewhere in the global food market. Ultimately, innovation based food research will need to be supported by realistic scale up, development and commercialisation opportunities taking into account sustainability and geographical constraints.

Research Objectives:

- Use the new chemistry and processing infrastructure to support physical and colloidal sciences to develop new food structures;
- Development of new capability for shelf life studies through analysis of kinetic data – critical for development of dried ingredients for export;
- Strengthen scientific and technological expertise in food ingredients and nutritional beverages including infant, elderly, medical and sports formula;
- Develop a capability in meat science to enable the extraction and purification of innovative ingredients from primary production and waste streams;
- To mine the national food consumption databases to establish the population impact of the re-formulation of the nutritional composition of processed foods;
- To develop rapid on-line physical and chemical methodologies for measurement of food safety and quality in particular meat eating quality;
- To develop science based technologies to reduce the need for salt, fat and sugar in food manufacturing while maintaining consumer acceptance.

4.1.2 KEY INVESTMENT AREA - SENSORY SCIENCE

Ireland is well positioned to continue to develop basic sensory research expertise. National and international research and capital funds have enabled the establishment of some research infrastructure, in terms of state of the art sensory suites, and bespoke analytical equipment. A wide range of projects involving sensory science supported by national funds allowed Ireland to develop expertise in sensory evaluation of foods. Likewise there has been some investment in advanced technology to support flavour and taste chemistry. However, further investment is required to improve consumer and preference testing through advanced methodologies including flavour chemistry. A national food industry requirement is to expand Ireland's capabilities in these areas.

Research objectives:

- Establish a Network of Excellence in Sensory Science to facilitate the needs of industry which would include:
 - studies to improve consumer acceptance and preference testing methodologies
 - studies to support better understanding of the drivers of consumer preference
- Support basic research in the following areas:
 - The development of sensometric methods to correlate descriptive analysis and analytical chemistry data for odour and taste;
 - An analysis of factors influencing sensory acceptance by consumers and particularly food acceptance by the elderly;
 - Studies on the impact of sensory attributes on satiety;
 - The development of models to predict interaction of food and drinks in a meal situation;
 - An analysis of the impact of cultural difference in product acceptance, in terms of niche markets and exports.
- To identify the specific sensory and nutritional needs of the older population and to advance the development of new and reformulated foods for that age group;
- Development of a new research capability in Ireland to support the area of flavour chemistry and linking sensory characteristics of foods with structure.

4.1.3 KEY INVESTMENT AREA - NOVEL PROCESSING TECHNOLOGIES

There is a wide recognition that product and process innovation will enable the food industry to remain profitable and competitive. A multidisciplinary research approach to product and process development is required, involving expertise in food technology, food science, food microbiology, food chemistry, food engineering and food flavour targeting opportunity areas.

Despite the scientific research on alternative processing technologies in recent years, there remains a void in scientific knowledge on the impact of these technologies on foods; and many potential applications have yet to be identified. Novel technologies could lead to the development of innovative processes that offer major economic benefits to industry. Industry have identified areas such as reduced processing times, enhanced process yields, improved food safety/stability and increased product quality, as improving the competitiveness of the Irish food companies and supporting the delivery of premium quality innovative consumer products.

Encouraging the uptake of these alternative production processes by Irish companies is essential to the future of the food industry. The state has enabled the existing research infrastructure in novel processing methods and it is vital to continue to build on and deploy these capabilities for the benefit of the food industry and the food consumer. Research areas to be targeted include:

Research Objectives:

- Investigating the use of innovative processes and technologies for enhancing functionality and structure of foods;
- Use of novel technologies to reduce and control biofilms, dried surface contaminants and environmental decontamination in food production environments;
- Novel approaches to spore control in food products;
- Optimising food manufacturing to enhance its quality and safety especially in the meat industry (chilling techniques, packaging systems);
- The use of novel technologies for recovering high added value ingredients for the food and pharmaceutical industry from plant (e.g. seaweed, barley or apples) or animal (e.g. fish or lower value meat cuts and by-products or for adding further value to traditional dairy ingredients) sources;
- The use of novel technologies in production processes to retain bioactivity functionality of high-value products and quality;

- Evaluating the effectiveness of alternative heating methods for reducing energy consumption (with reductions in associated GHG emissions and benefits in terms of leaner manufacturing) in food processing environments while producing high quality products;
- The development of novel sensing technology for improved process control based for example, on hyperspectral imaging.

4.1.4 KEY INVESTMENT AREA - ENCAPSULATION

Microencapsulation was a key focus of earlier national food research efforts, including large industry-led initiatives to protect and deliver bioactive compounds. Research expertise and a significant research infrastructure was established through nationally funded projects. Excellent progress has been made in the design and manufacture of encapsulating matrices and novel methods have been developed to assess bioavailability and to enhance the absorption of bioactives. New encapsulation technology research will be able to position Ireland's ingredient industry as market leaders in encapsulated bioactive ingredients capable of supplying the global food industry. This research will also deliver on the opportunity to develop novel nano-vectorised delivery systems. To realise these major opportunities, further development of encapsulation technology is required.

Research objectives

- Protect heat sensitive ingredients such as enzymes and bioactives during heat processing and other harsh regimes used in the industrial manufacture of food products;
- Control the interaction of bioactives with the food matrix, ensuring a timed-release delivery;
- Protect ingredients from early digestion in the gastro-intestinal tract;
- Target release the ingredient in order to optimise bioavailability in the gut;
- Mask the taste of ingredients that have a strong or unacceptable taste by providing a barrier between our taste buds and the ingredient;
- Use of novel technologies to enhance shelf life of seafood products.

4.1.5 KEY INVESTMENT AREA - NANOTECHNOLOGY

State investment in research to support the development of nanotechnology is on a par with that of the US and Germany; as a result, the quality of Irish nanotechnology research is recognised internationally. Public health and life science are the main economic drivers of nanotechnology. Despite having expertise in nanotechnology research, there remains a limited application in food related areas in Ireland. This is in direct contrast to the activities in other European countries where food companies have a direct involvement in nanotechnology research. Nanotechnology offers the potential to enhance the safety, shelf-life and health benefits of food and offers the industry new processing capabilities, which can enhance competitiveness. To ensure that Ireland's investment in nanotechnology can be translated in to food research, investment is required.

Research objectives:

- Risk/Benefit assessment of nanotechnology in foods;
- Identification of the safety aspects of nanotechnology in food product development and processing;
- Nanoprocessing as a means of concentrating bioactives;
- Targeted delivery of nutrients using nanocapsules;
- Detection of food contamination using nanosensors for shelf life improvement;
- Nanotechnology to create packaging which will extend the shelf-life of food and enhance food safety.

4.2 FOOD PROCESSING TECHNOLOGIES

Consumer Drivers: The consumer wants high quality novel and /or modified products with improved and attractive taste and convenience characteristics.

Industry strategic agenda: Ireland’s food industry has to meet exacting consumer requirements. Most fundamental in achieving this broad set of goals is a detailed understanding of the sensory attributes of food. Companies want to know how different process technologies, the formulation of flavour and texture compounds and the use of different carriers of bioactive ingredients can affect consumer choice. Being able to “hide” the taste of some food materials would offer opportunities for firms to become more competitive. Research into methods of encapsulation that in addition to hiding flavours can enhance the stability, bioactivity and delivery of food ingredients is relevant to all food sectors and is, therefore, essential in the development of Ireland’s food industry.

Main Investment Areas

Food Processing Technologies
Food structures

Supporting investment Areas

Novel processing technologies
Sensory science
Encapsulation
Nanotechnology
Food chemistry & formulation
Nutrition
Consumer research
Food safety & quality

ALIGNMENT OF THE PROPOSED FOOD PROCESSING TECHNOLOGIES RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA:

There is a requirement across all sectors within the food industry to understand the effect of processing on the structure of foods. Industry research needs in this area point to the acquisition of knowledge of the impact of food structure on the final product quality, on the efficacy and sensory properties of ingredients and the influence of food structure on the bioactivity of functional ingredients. The structure of the foods, which incorporate bioactives could influence their bioavailability, absorption and efficacy, and research in these areas is consistent with European Food Safety Authority (EFSA) requirements with respect to health claims.

The availability of efficient and effective food processing technologies is critical to the economic development of the Irish food industry. In seeking to achieve a leadership position in key markets, Ireland’s food sector has always attempted to respond to consumer demands by utilising the most effective means of producing high quality products. The introduction of new food processing technologies and the optimisation of existing technologies and processes can support the development of the sector by equipping it to deliver products that improve health, well-being and longevity; further develop consumer trust in the increasingly complex food chain; and address exacting standards in respect of sustainable and ethical food production.

Ireland’s food industry faces global challenges from consumers that demand healthier, safer, more convenient and ‘less processed’ foods. In responding to industry calls to develop novel processing technologies, it is essential that core research skills in more traditional processing techniques such as separation and drying; chilling and freezing; pasteurisation; sterilization; mixing and formulation technologies are retained. Whilst directing research towards new methods that offer faster and milder processing methods, it is important that the effect of these methods on the sensory attributes of food can be assessed with equal efficiency.

Sensory analysis is a cross-cutting capability required by all food sectors and is relevant to consumer products and food ingredients alike. The impacts of new processing technologies and formulations on the sensory attributes of products have to be assessed, as does the introduction of novel ingredients. Attempts to improve or otherwise enhance the flavour and texture of foods also require extensive sensory research and sensory research is needed to support efforts to “re-engineer” foods to allow them to meet new consumer trends. It is essential to expand Ireland’s sensory analysis and research capabilities; aligning them towards providing greater support to industry.

Capturing opportunities to create functional foods based on fish, meat, dairy, algae or plants are likely to require a high level of knowledge of encapsulation technologies. Research is required to ensure that bioactives included in the food matrix remain stable and that delivery is precisely targeted. Developing non-food uses for food bioactives, as planned by industry for some marine ingredients, will rely on encapsulation technology to enhance the stability, bioactivity and delivery of these bioactive compounds.

As with food product development and innovation, scale-up of research outputs to industrial production will be a critical factor in ensuring maximum value from the investments made in research and a key enabler of growth within our industry.

4.2.1 KEY INVESTMENT AREA –FOOD PROCESSING TECHNOLOGIES

Investment in food processing technologies is critical to underpin and facilitate successful product development, scale-up and commercialisation of premium, value added food products enriched with ingredients, e.g. ingredients developed as part of mining milk or marine species. Conservation of structure and functionality of such ingredients in formulated food systems throughout processing and shelf-life is essential. Significant State investments in recent years in processing technology research and development infrastructure (i.e. FIRM Strategic Equipment Initiative, PRTL) have facilitated development and expansion of resources and facilities in the area of food processing technology.

The expected increase in the global population and the rise of the BRIC’s, provides a long term opportunity for Ireland, especially for the dairy sector. To ensure maximum exploitation of this opportunity, research capability in the areas of dehydration, separations and thermal processing will have to be supported to allow access by Irish food manufacturers to these emerging markets. With the targeted increase in milk production, Irish dairy processors can only address this growing market opportunity through dehydration (spray drying) / concentration of milk. In addition, research is also required in the area of food preservation to ensure foods retain their functionality and quality during transport and storage. These new preservation processes will require innovative packaging solutions which in some instances, will drive the processing innovations.

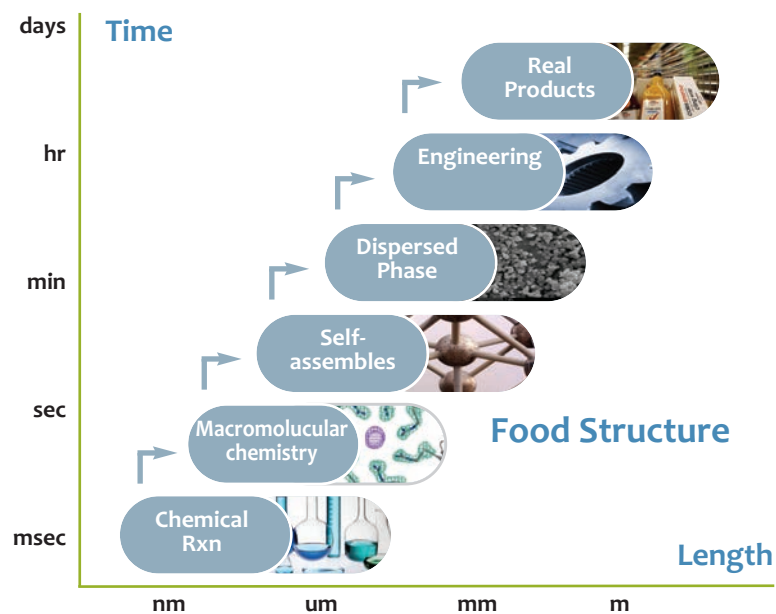
Whilst microbiological and chemical stability of formulated food systems are important, the physical stability of such products is a key determinant of their consumer acceptability. In the context of accessing global markets, research into the complex interactions between ingredients, processing technology/parameters and storage/transport conditions determining the overall structure and physical stability of food systems is needed. For example, research into the physical stability and reconstitution properties of milk powder products exported to Asia for use as is or as ingredients in formulated food products will be required. It should be noted that developments in processing technology will have to be underpinned by food chemistry and nutrient interactions supported by colloidal and physical (including materials) science.

In addition, traditional as well as novel processing technologies can address more fundamental challenges that face the food industry as well as enhance competitiveness. No more so than in the beef sector, where a major challenge exists in reducing greenhouse gas emissions by adopting more energy efficient heating methods from what is a high-energy demand industry, associated with processing. Scope also exists to transfer heating technologies to other sectors such as dairy, beverage, marine and prepared consumer foods, all of which have high-energy processing demands.

Research objectives:

- Development of new food processing technologies underpinned by food chemistry coupled with colloidal and material sciences;
- Develop new and more energy efficient ways of dehydrating, separating / fractionating and thermally processing food;
- Develop longer shelf life ingredients and foods with robust sensory (flavour and texture) characteristics capable of withstanding dehydration and thermal processing;
- Develop new processes to produce safer, healthier and flavoursome traditional products (eg low salt cured products);
- Re-engineering of existing processes for more energy efficiency;
- Investigate changes in sensory characteristics during processing;
- Develop the scientific knowledge of the complex interactions between ingredients, processing technology/ parameters and storage/transport conditions.

Figure 4.2.2-1: The relationship between particle size and time in the context of food structure research.

**4.2.2 KEY INVESTMENT AREA - FOOD STRUCTURES**

Food structure determines the processability, stability, sensory attributes, digestibility and bioavailability of foods. Food structure can be examined on many scales from nano to macro scale as indicated in Figure 4.2.2-1.

Developing a complete understanding of food structure will facilitate the formulation of tailor made food products and in doing so provide industry with a more robust food formulation approach. In addition, a thorough understanding of the chemistry and technology of structuring agents in food systems (i.e., proteins, carbohydrates, enzymes and emulsifiers) is required to facilitate development of new and exciting food structure concepts (e.g., whey protein based nanofibrils, double emulsions, controlled aggregation and encapsulated systems).

Research Objectives:

- Development of advanced techniques to characterize food structure;
- Elucidation of the effects of processing on food structure. Particular focus on industrially relevant processes is required;
- Investigate the effect of food structure and physical stability of food systems using microscopic, rheological and reaction kinetics techniques;
- Development of realistic digestive models to observe the digestibility of foods with diverse structures;
- Establishment of the role of food structure on nutrient bioavailability;
- Determination of the role of food structure on sensory attributes of foods;
- Evaluation of food safety issues surrounding food structure.

4.3 FOOD AND HEALTH

Consumer Drivers: As modern lifestyles create new health challenges, maintaining or improving health and wellness has become a well established priority in many people’s lives. As health infrastructures feel the strain of rising demand and falling support, the responsibility for people to find their own path to good health has become more important.

Industry strategic agenda: New markets of “wellness” and “nutritional” products present Ireland’s food industry with new product opportunities. An ability to model the impact of new and reformulated food product composition on consumers is essential. Likewise, attempts to develop novel food ingredients, including bioactive ingredients, is reliant on nutritional biochemistry expertise, molecular biology and the capability to design and perform dietary intervention trials to substantiate health claims. The development of research expertise in personalised nutrition is a prerequisite for capturing a share of the emerging personalised health market.

Main Investment Areas

Functional ingredients/foods
& Bioactives
Gut Health
Nutrition

Supporting investment Areas

Consumer research
Sensory science
Encapsulation
Nanotechnology
Novel processing technologies
Food structures
Food chemistry & formulation
Food safety & quality

ALIGNMENT OF THE FOOD AND HEALTH RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA:

The development of new products aimed at the nutrition and wellness markets, either through re-formulation of existing products or the development of new functional foods are exciting opportunities for Ireland’s food sector which already has significant global strength in food ingredients and nutritionals. Research knowledge and capability is required to continue to support this opportunity which already builds on significant national research expertise. Through Food for Health Ireland (FHI, the industry led collaborative research centre in milk mining funded by EI and the dairy industry²⁵), investments under the Food for Health Research Initiative (cob-funded by DAFM and HRB²⁶) and the marine functional foods research programme – Nutramara (cob-funded by DAFM and MI²⁷) substantial funding has led to a research footprint that is industry aligned and scientifically competitive internationally.

This footprint should be further strengthened to “future proof” the sector. For example, in planning the re-formulation of foods, companies and regulatory agencies need to be able to model the relative impact of such changes in food composition and consumption patterns. In developing novel food ingredients on which to base functional foods, research on bioactives from the dairy, marine, horticulture, cereals and meat sectors requires the input from clinical practitioners and nutritional biochemistry that exploits modern molecular biology tools. Access to and maintaining the national food consumption database and other relevant nutritional surveillance databases are vital. The FSAI has successfully used this approach in studies on salt and folic acid and is planning similar activities with industry with regard to saturated fats. In addition, these databases can be used to underpin public health policy. This screening has to be supported by the design and implementation of dietary intervention strategies. The National Nutrition Phenotype Database (JINGO) will be of considerable value in developing potential biomarkers which can eventually be used as the end points in the evaluation of dietary intervention studies with novel bioactives.

²⁵ www.fhi.ie

²⁶ <http://www.agriculture.gov.ie/research/foodinstitutionalresearchmeasurefirm/firmfoodhealth/>

²⁷ www.nutramara.ie

The meat, dairy, marine, horticulture, cereals and prepared consumer foods industry representatives identified functional ingredients/foods and bioactives as a development opportunity. There is a requirement for robust scientific research to underpin health claims, create niche products with added health and wellness benefits and to fully understand the contribution of such products in addressing the grand societal challenge of increasing levels of diet related diseases such as obesity and type II diabetes.

Developing a solid scientific and clinical understanding of the role of specific ingredients in gut health will provide key opportunities to innovate across all Irish food sectors. Examples of where this knowledge is relevant include the use of plant fibres and complex carbohydrates from milk, marine macroalgae, bacteria, yeast and cereals as prebiotic and other biofunctional ingredients, the role of dairy proteins and plant fibre in satiety and weight loss, the role of meat protein and extracts for modulating gut function and the beneficial effects of phytochemicals from vegetables. The ability to isolate, enrich and/or develop such bioactive ingredients will need to be underpinned by strong scientific expertise in food chemistry and technology. Examples of ingredients, which have allowed for increased added value from a dairy perspective, include human milk oligosaccharides, alpha-lactalbumin and lactoferrin, which were developed largely using membrane and chromatography-based separation technologies. Research and advancements in traditional and novel food processing technologies (e.g., thermal processing, emulsification/ encapsulation and drying technology) will be essential to successfully incorporate such new ingredients into next generation infant formula and others foods for particular nutritional uses while conserving biological efficacy in a safe and stable product matrix.

Lifestage nutrition is an area which captures the potential for the confluence of a significant food industry base, macro market trends and demographics, existing R&D capability and strategic commitment. Ireland produces approximately 15% of global exports in infant milk formula. This market is based entirely on milk supplied by Ireland's dairy

industry. Understanding the role of infant milk formula ingredients on gut functioning and on infant health is fundamental in realising opportunities in the design and production of next generation infant formula.

The global population of the elderly is set to increase dramatically in the next two decades. This demographic change is a major opportunity for Ireland's food companies, particularly those involved in the production of foods for particular nutritional uses. The knowledge and expertise gained in understanding the gut flora of the elderly, the changing food consumption patterns of the Irish population and the link between diet and nutritional phenotype will enable and scientifically underpin the design of ingredients that address the specific health needs of all consumers as they progress from early infant development to healthy ageing.

4.3.1 KEY INVESTMENT AREA – FUNCTIONAL INGREDIENTS / FOODS AND BIOACTIVES

In response to predictions regarding international market growth and national public health concerns, there is a wide interest in functional ingredients / foods and bioactives research in Ireland. As a result of significant recent investments, Ireland has well established food research capabilities and critical mass in dairy, marine, cereals and plant bioactive research.

In the case of the dairy sector, the focus is on intelligent milk mining, the screening of candidate peptides and oligosaccharides for bioavailability and bioactivity exploiting the various omics technologies, process scale-up, encapsulation, food formulation and ultimately their evaluation in dietary intervention studies. However, in addition to mining approaches, continued investment is required in traditional technologies for the identification, isolation and enrichment of selected intact bioactive food constituents. Examples of such components include oligosaccharides,

lactoferrin, immunoglobulins, growth factors etc, manufactured using membrane separation technology, ion exchange chromatography and physical separation technologies. Funding in this area has significant potential to add value to existing commodity type dairy ingredients and products, on a scale sufficient to contribute to achieving the growth projections put forward in the Food Harvest 2020 report. Also requiring future investment is the study of the relationships between food processing (using traditional and novel technologies), bioavailability and bioactivity (e.g., the role of protein denaturation and aggregation on digestibility and bioavailability).

Marine bioactive research is focused on the biological and chemical characterisation of polyphenols, peptides, polysaccharides, amino acids, lipids, protein hydrolysates and materials with antioxidant properties, extracted from marine species and marine food processing waste.

The emphasis of phytochemicals research is on the role of agronomic and post-harvest practices on phytochemical levels and on the use of novel processing to retain phytochemical activity in food products with a high level of consumer acceptance as well as improving our understanding of the mechanisms of action of plant derived bioactives. A number of related projects are examining botanicals and plant foods as sources of novel and new molecules for inclusion in functional foods.

Linked to the discovery of new bioactives from natural resources is the extraction of bioactives from existing resources. A key opportunity for the food sector, particularly the meat, seafood, fresh cut produce and horticulture sectors is the valorisation of processing waste. By developing strategies for the recovery of biologically useful compounds from processing waste streams, new revenue streams will be developed, waste minimised and the impact of disposal on the environment reduced.

Research Objectives

- The development of a national network of excellence on bioactive development to maximise Ireland's linkages to FP7/Horizon 2020 and possibly any JPI initiative in this area;
- Development of industrially relevant and cost effective processes for the manufacture of efficacious, concentrated and shelf stable bioactives;
- Food formulation to enhance the delivery and sensory quality of bioactives;
- Further developments in model systems to predict the digestion, absorption and bioavailability of bioactives;
- Probabilistic exposure modelling for dietary intake of bioactives under different scenarios;
- Technological platforms for transfer of bioactive food components from laboratory scale to pre-commercial;
- Develop the knowledge base for production and stabilisation of food ingredients and foods with functional and bioactive components;
- Maximise Ireland's marine biological and food sciences expertise to identify marine materials, organisms and extracts with functional food potential;
- Development of a national database and repository of biologically active compounds and extracts derived from terrestrial and marine sources;
- Integrated strategies for the recovery of bio-active components from food waste;
- Mining for and optimization of the use of natural preservatives.

4.3.2 KEY INVESTMENT AREA - GUT HEALTH

The gut is the primary site of interaction of food within the human body: it plays essential roles in digestion and nutrient uptake, in susceptibility to infection, in the immune system and in neurological sampling. Moreover, many human diseases, including inflammatory conditions (e.g. Irritable Bowel Syndrome (IBS) and Inflammatory Bowel Disease (IBD)), cancer, infection, obesity and heart disease are known to involve the gut. The gut is also home to trillions of bacteria, the 'Microbiota', which can be considered as a virtual organ. It is only recently that the full role of these bacteria in human health has been appreciated. Emerging research is demonstrating that the composition of the microflora changes with diet, age, Body Mass Index and overall health status (though it remains unclear whether this is causal or consequential). Moreover, our microbiota is responsible for the production of a vast array of pharmabiotic substances which directly or indirectly impact human health.

The role of food in the development and maintenance of gut health, as outlined above, represents a major opportunity for the food industry. Responding to the challenge of developing functional foods (including probiotics and prebiotics) and other bioactive ingredients requires a wide range of research expertise. The imperative of such research is all the more important in developing infant milk formula and diets for the elderly because dramatic changes take place in gut functioning at the extremes of life.

Research that increases our understanding of the role of food in influencing the microbiota, gut health and disease prevention, will lead to food processing innovations and new food products based on food ingredients which promote gut functioning and the development of a healthy microbiota.

Research Objectives:

- Development of improved methodologies to understand gut flora composition including bioinformatics, metagenomics and metabolomics;
- Determination of the role of diet (human milk to infant milk formula) in the establishment of a healthy microbiota in the infant;
- Determination of the role of diet in programming a healthy microbiota in the elderly;
- Development of new and existing probiotic cultures for gut health improvement - from isolation to clinical evidence;
- Development of prebiotic ingredients which positively impact on gut flora and consequently improve health;
- Development of food systems for delivery of efficacious probiotics and prebiotics - including innovations in drying, encapsulation and food structure;
- Development of food ingredients which have a positive modulating role on the immune system and/or in counteracting human infection;
- Determination of the role of food ingredients in the uptake of nutrients and in energy harvesting by the gut.

4.3.3 KEY INVESTMENT AREA - NUTRITION

Ireland's nutrition research capabilities are extensive and embrace the areas of public health nutrition and nutrigenomics. Both of these areas are now being integrated into a single approach to study the impact of diet on our population health. From a national research perspective, it is important to link food research to its health dimension. There are three elements to nutrition research that need to be considered:

- Food consumption survey
- Human intervention studies
- Nutrigenomics

The available suite of Irish dietary and food consumption surveys, and related nutritional surveillance databases meet the highest international standards. These databases can provide food companies with brand specific food; nutrient intake data for all groups within the Irish population and detailed food ingredient and packaging material data. These databases play a central role in the study of acute and chronic food chemical exposure and have / can be used for risk management in relation to possible food contamination instances and are also important for chemical and microbiological risk assessment.

In addition, long-term, longitudinal studies and randomly controlled dietary intervention studies, as funded through various agencies (FIRM, HRB, Wellcome Trust, Food Standards Agency, European Commission Framework Programme), are a key strength in Ireland's institutionally based nutritional research activities. Obesity and associated chronic diet related diseases, together with an insufficient nutrient supply in subgroups of the population, are likely to remain major health concerns for at least 20 years. Coupled with the special nutritional demand in aging societies, they demand immediate measures for improvement. The projected changes in both population demographics and life-span demand that European public health policies focus on 'healthy ageing'.

Ireland has established a major international lead in the integration of public health nutrition and nutrigenomics data and has access to genomic data and in most cases, to metabolomic, proteomic, transcriptomic and imaging data. Just as several genetic variants contribute to the risk of any particular illness, it is clear that different variants affect the absorption, metabolism, catabolism and excretion of nutrients. These in turn dictate individual nutrient requirements and are the basis of "personalised nutrition". Identifying and addressing such nutritional variants, opens up opportunities for Irish food companies to create new markets for specialised food products.

Research Objectives:

- The development of potential biomarkers which can eventually be used as the end points in the evaluation of dietary intervention studies with novel bioactives;
- Exploitation of existing databases to inform new product development for Irish food companies in the context of lifestage nutrition;

- Where health claims are intended for particular food products, appropriately designed acute, chronic and acute-on-chronic human intervention studies should be included in many of the proposed research areas;
- Existing national databases need to be updated on a regular basis to ensure the currency of the data for addressing nutrition and food safety issues, and also be thoroughly interrogated and exploited to underpin public health policy, especially for infants, the elderly and those suffering from diet related diseases including obesity and Type II diabetes. To maximize their value and ensure international recognition, these databases should be linked to comparable resources in other EU member states to maximize their value. This should be facilitated through the Joint Programming Initiative "A Healthy Diet for a Healthy Life";
- A nutrition research programme which considers the following:
 - the use of food based strategies in the prevention of nutrient deficiencies;
 - the impact of nutrition, maternal health and prenatal programming as determinants of longer-term healthy ageing, including skeletal and metabolic health;
 - the use of new and effective food-based strategies to optimise lean body mass in the older population, including maintenance of muscle function and prevention of osteopenia, osteoporosis and cognitive decline;
 - the use of the Internet to collect dietary data should be developed drawing on expertise in nutrition, software engineering, social network and marketing;
 - the exploitation of existing databases to link genotype with phenotype (physiological and clinical) and ultimately with biomarkers;
 - the exploitation of existing databases to establish metabotypes and nutritypes, i.e. clusters of individuals sharing similar metabolic signatures and food choice; and the development of urinary biomarkers of habitual dietary patterns
- Enhancement of the health promoting potential of fruits, vegetables and cereals through the development of customised agronomic and processing practices.

4.4 FOOD BUSINESS AND CONSUMER SCIENCE

Consumer Drivers: As modern lifestyles create new health challenges, maintaining or improving health and wellness has become a well established priority in many people’s lives. As health infrastructures feel the strain of rising demand and falling support, the responsibility for people to find their own path to good health has become more important.

Industry strategic agenda: There is a clear recognition across Ireland’s food industry of the need to secure a deeper understanding of factors which contribute to the success of food enterprise activity. An imperative in all food sectors is to gain insights into the determinants of consumer behaviour, thereby strengthening the food firms’ understanding of consumer needs. Data generated by consumer research will help firms to identify new food product opportunities and allow firms to maximise their performance in chosen markets.

Main Investment Areas

Consumer research

Supporting investment Areas

Sensory science
 Nanotechnology
 Functional ingredients/foods & bioactives
 Food chain integrity
 Food chain sustainability
 Nutrition

ALIGNMENT OF THE PROPOSED FOOD BUSINESS AND CONSUMER RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA

Food Harvest 2020 recognised the need for in-depth knowledge and understanding of consumer preferences and trends to help the agri-food and fisheries businesses to better predict and prepare for future opportunities. Developing insights in to the needs of consumers and end users allows food companies to anticipate and prepare for the introduction of new products and even influence how firms process food products or from where ingredients are sourced. A consumer focussed framework is presented in Food Harvest 2020 which highlights the importance of continuous feedback and discourse between all stakeholders and the consumer to understand and respond effectively to future needs and concerns of consumers.

The need for consumer studies is identified in many aspects of the industry strategic research agenda ranging from consumer acceptance of new foods to drivers of consumer attitudes to nutrition and physical activity. Rapid changes are taking place in demographics, national and global economies, life-styles and health issues, all of which shape food company performance. Consumer choice is dynamic, fluctuating in times of recession and growth, and can influence market structure. Product lifecycles are affected by consumer trends. Being able to understand the factors which fashion the lives of consumers, whether from social, technological, economic, environmental or even political change is essential in developing food products.

4.4.1 KEY INVESTMENT AREA - CONSUMER RESEARCH

Research into the food related behaviour of consumers on the island of Ireland has developed greatly in recent years. The continuous assessment of consumer trends by Bord Bia and of consumer food behaviour by SafeFood is complemented by the strong consumer research capabilities of the higher education sector and in research institutes. The results from national and international funded research projects provides some insights into consumer food choice and consumer behaviour and has helped to identify some of the key challenges which Ireland's food sector face. There is also a need to increase our understanding of consumer behaviours in global markets if we are to access those markets effectively. Therefore, research investments in this thematic area should include an international dimension. In addition, research activities in this area need to recognise the current industry configuration as being strong in respect of business to business (B2B) and somewhat weaker in respect of business to consumer (B2C) with the former being the immediate focus of future research activities.

Despite the recent major efforts to promote healthier eating and better food safety behaviour among consumers, large proportions of the population have poor food safety and nutrition knowledge, engage in unsafe food practices and consume unbalanced diets. Even for those who know what they should do and wish to be healthy, conflicting factors such as time poverty, low willpower, temptation, habit and cost present significant barriers to making any improvement. Certain groups are more at risk; particularly the low income groups, those with low education levels, young people and men. To date, the importance of many determinants of food and health behaviour remains to be investigated. Little research has been conducted on how best to promote behaviour change in Irish population groups. In recent years Ireland has experienced a number of food safety incidents and while consumer attitudes remain largely positive, understanding how to maintain and support this confidence is needed.

The development of new food products or processing techniques, particularly those that use genetic modification and nanotechnology require new insights into consumer acceptance attributes.

Research Objectives:

- Investigate the influence of wider environmental issues on consumer related behaviours;
- Investigation of consumer attitudes to novel food technologies;
- In relation to food safety:
 - The fragmentation of consumer communications channels and the emergence of social media require the development of novel communications models for effectively communicating on food safety issues with consumers;
 - Need to identify key methods to improve food safety knowledge among consumers on the prevention of food borne illness in the home, particularly in groups such as young men and to understand the knowledge-behaviour gap in consumer domestic food safety behaviour;
- In relation to public health, research on effective interventions to induce behaviour change on the island of Ireland particularly where those interventions can have a positive impact on public health and in particular for men, teenagers, children and those from low-income groups;
- A National Network of excellence on the determinants of food choice and physical activity should be established to maximise Ireland's potential to participate in Horizon 2020 and the JPI 'A Healthy Diet for a Healthy Life';
- A longitudinal survey of knowledge, attitudes, perceptions, behaviour and their determinants conducted on an island of Ireland basis, and cognisant of similar international surveys, to better understand the drivers of consumer choice and behaviour in order to inform industry and policy makers.

4.5 FOOD CHAIN INTEGRITY AND SUSTAINABILITY

Consumer Drivers: Despite the economic downturn, a growing number of people are looking for companies and products they feel they can trust. Consumers are seeking stronger relationships with the products and brands they buy, often seeing traditional methods as a mark of trust and integrity. Consumers are increasingly more aware of the negative impacts of their actions on the environment and are supporting companies with more environmentally friendly approaches to production.

Industry strategic agenda: Due to rising energy costs, climate change, and an increased awareness by consumers of the ‘carbon footprint’ concept, food chain integrity and sustainability has become a significant issue for all sectors within the food industry.

Main Investment Areas

Food chain integrity
Food chain sustainability

Supporting investment Areas

Food safety & quality
Consumer research

ALIGNMENT OF THE PROPOSED FOOD CHAIN SUSTAINABILITY AND INTEGRITY RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA

The EU Climate Change Package presents a significant challenge to the Irish agri-food industry to play its part in helping to meet Ireland’s target of a minimum 20% reduction in greenhouse gas (GHG) emissions by 2020. Modern food production and processing systems have a high environmental impact. In order to meet the target of a 20% reduction in emissions, all parts of the food production and supply chain will have to be more aware of their future energy and water use and the huge potential cost savings if usage can be reduced. Nonetheless, energy and water are vital components of

safe food production & processing and a fine balance between safety and environmental goals will need to be struck in order to ensure consumer trust in the food supply.

The efficiency of the food supply chain is far from optimal with many supply sources and intermediate stages in production and distribution²⁸. By embracing and promoting sustainability in food production, Ireland can position itself as a world leader in emerging international trends. A smart approach will seek to link sustainability with increased industry efficiency while, at the same time, clearly articulating the benefits to consumers as a market positioning strategy that supports premium returns to the sector and encourages best practice²⁹. The implementation of technologies, introduction of changes in business practice and the instigation of cultural adaptations to ensure competitiveness of the business is not diminished are required to enhance the sustainability of the processing sector. The Institute of International and European Affairs (IIEA) lists five elements which should be considered in any sustainability enhancement programme including energy efficiency, waste reduction, transport efficiency, air quality and water utilisation³⁰.

Bord Bia, working with the Carbon Trust, has recently completed the Beef Quality Assurance Scheme Environmental Pilot, concentrating in the first phase on the production end of the supply chain. The pilot is the first national quality assurance scheme to include environmental sustainability criteria. The next phase will be to go beyond the farm gate to the processing sector. Bord Bia will also be extending the programme to other products – starting with dairy.

Research investments in this thematic area will be supported through cross-sectoral research programmes to ensure that all elements of the food supply chain are considered and addressed. The AREA group will also consider sustainability and integrity in the Strategic Research Agenda for the agriculture production sector. Similarly, Sea Change addresses this in the relation to the fisheries sector.

²⁸ ETP “Food for Life” – Strategic Research Agenda

²⁹ Food Harvest 2020 – A vision for Irish agri-food and fisheries.

³⁰ From Farm to Fork: A sustainability enhancement programme for the Irish Agri-Food Industry (2009) Institute of International and European Affairs.

4.5.1 KEY INVESTMENT AREA - FOOD CHAIN INTEGRITY

A key issue in terms of food chain integrity is to support Ireland's food industry to operate to the highest international standards in terms of sustainable production. Research is required to provide industry with the essential knowledge with which to maintain the quality and safety of food throughout the food supply chain – many of the research objectives in relation to food safety are addressed in Thematic Area 4.6. Research in this area must involve the production aspects of the food supply chain.

Research Objectives:

- Develop strategies for improving productions systems, packaging systems, maintenance of the cold chain and implementation of statistical process control at key points in the process chain to ensure integrity within the food supply chain;
- Development of smart sensor systems that allow safety and quality of foods to be monitored in real time and in a cost competitive fashion throughout the food supply chain;
- Improve food production systems through the application of Life cycle analysis methodology;
- Valorisation of by-products from the food processing industry;
- Development of risk assessment models for marine foods;
- Research on waste reduction with a particular focus on (i) Biological Oxygen Demand (BOD) reduction to minimize effluent treatment costs and (ii) water use reduction and water recycling.

4.5.2 KEY INVESTMENT AREA - FOOD CHAIN SUSTAINABILITY

An important strategic theme emerging in consumer consciousness is that of environmental sustainability. This primarily incorporates environmental concerns but also reflects growing interest in issues of simplicity, authenticity, heritage and animal welfare. Therefore, product offerings that capitalise on these trends must be credible and proven. In addition, coping with the projected increase in world population and the associated demand for food, requires major improvements in food production efficiency. The ability of Ireland's food industry to realise the growth potential as outlined by Food Harvest 2020, is dependent on it being able to achieve increases in primary production and food production output, with regard for environmental, nutritional, economic and social objectives. Realising the vision of Food Harvest 2020 requires research that helps industry to address the many challenges associated with making optimal use of raw materials, water, energy and other resources, while maintaining rigorous food quality and food safety standards that meet consumer and legislative requirements. Similar to food chain integrity, research in relation to food sustainability must involve the production aspects of the food supply chain.

Research Objectives:

- Development of indicators of environmental quality for food products;
- Development of a life cycle analysis methodology for the food sector;
- Development of metrics of sustainability for food products;
- Traceability within the food chain with respect to by-products / waste of the food processing industry being used to support production.

4.6 FOOD SAFETY AND QUALITY

Consumer Drivers: As a basic prerequisite consumers demand food safety and call for transparency in food production. People have been calling for and expecting transparency from companies for some time, and the current economic climate has only heightened people's desire to understand the processes that underpin food safety and quality.

Industry strategic agenda: All food producers are conscious of their prime responsibility to protect consumers from food borne risks. As industry adopts new production methods, incorporates novel materials in food products and responds to consumer demands, maintaining food safety controls is essential. Ireland's food industry requires research knowledge that will help it to maintain guarantees of food traceability, authenticity and food safety throughout the food chain, right up to consumption. Particular challenges facing industry include the introduction of new production methods, food ingredients, access to rapid test methods, and compliance with regulatory systems in ways which ensure consumer safety is not compromised.

Main Investment Areas

Food safety & quality

Supporting investment Areas

Nanotechnology
Encapsulation
Food structures
Food chemistry and formulation
Sensory science
Nutrition
Food processing technologies
Novel processing technologies
Functional ingredients / foods & bioactives
Food chain integrity
Food chain sustainability
Consumer research

ALIGNMENT OF THE PROPOSED FOOD SAFETY AND QUALITY RESEARCH WITH THE FOOD INDUSTRY STRATEGIC RESEARCH AGENDA:

The sustainability of Ireland's food sector is integrally linked to its food safety performance. Protecting the consumer from food hazards is an industry priority. Across all sectors of Ireland's food industry, producers and processors face food safety and quality measures throughout the food chain. Food safety cannot be jeopardised in meeting consumer demands for minimally processed foods, or by the introduction of new process technologies and novel materials, designed to enhance competitiveness. A highly integrated approach to food safety and quality across the full spectrum of the food chain exists in Ireland. There remains however, an ongoing need to continuously develop a high-quality risk surveillance and risk assessment capability in respect of food borne hazards. Such an approach, which spans the entire food chain, benefits consumers, food producers and above all Ireland's international reputation. Therefore, it is essential that we maintain and develop the food safety expertise available to support the expansion of food innovation within the Irish industry; the protection of public health and to ensure the identification of emerging risks in the food chain.

4.6.1 KEY INVESTMENT AREA - FOOD SAFETY AND QUALITY

The production of safe high quality foods for the home and overseas markets, as envisaged by Food Harvest 2020, has been and should continue to be underpinned by the provision of guarantees of safety, traceability and authenticity to the consumer at the point of purchase and consumption. A fully transparent system, involving industry, academia, regulatory authorities and public health agencies, can assure food safety and quality, if underpinned by scientific knowledge in the areas of microbial and chemical contaminants, quality, traceability and authenticity.

Microbial hazards, including foodborne viruses, if present in the food chain will always be a threat to Ireland's brand reputation and to public health. For example, bacteria colonising the production chain are subject to food processing stresses designed to control them. However, some strains of bacteria alter their phenotype as a consequence of these control measures. This evolutionary phenomena can lead to harmful bacteria surviving along the food chain. Research that seeks to understand the underlying mechanisms that contribute to this altered microbial behaviour in the food processing environment is continuously needed. Research efforts, including the exploitation of databases, have contributed and should continue to contribute to the development of new food safety risk assessment models as well as developing the technical expertise and knowledge relevant to all sectors of Ireland's food processing industry; however, ongoing research is required.

Research Objectives:

- Isolation, characterisation and prediction of the behaviour of existing food-borne pathogens and emerging pathogens (new and those which are exhibiting antimicrobial resistance) in food systems, to facilitate decisions on metrics, to enable adequate control measures and their validation, and to support risk assessment;
- Investigation of the relationship between food processing stress(es) – such as heat, pH and others, encountered by zoonotic (food-borne) bacteria and their transcriptomes/proteomes, to uncover off-line mechanisms that can be translated into improved food safety controls;
- Predicting in a timely manner the emergence of new bacterial strains and serotypes of public health significance and the underlying role of horizontal gene transfer in the emergence of virulent bacteria such as verocytotoxigenic *E. coli* and bacteria with multi-antibiotic resistance;
- Application of predictive microbial modelling and risk assessment to predict public health risk posed by pathogens in particular food products and process chains and to strategically assess the benefit of risk reduction measures;
- Identification and development of antibacterial agents that are effective against key pathogens. Where appropriate, existing research knowledge should be further developed with a focus on application of such agents in key parts of the food chain from primary production (cattle, pigs, and poultry) through to decontaminants for animal coats, and carcasses to applications in food processing and distribution (packaging);
- Isolation, characterization and application of novel anti-fungal/anti-microbial compounds for use within the food industry including:
 - the application of natural antimicrobial compounds encapsulated in nanosomes as a means of reducing the burden of pathogens at primary production such as *Campylobacter* in the gastrointestinal tract of avians or *Salmonella* in pigs and also application of such nano-materials as part of a natural food packaging solution at the consumer end of the food chain;
 - increasing shelf life of food products including dairy, fish, meat, cereals and fresh cut produce;
- Development of quantitative risk assessments for key pathogen/commodity combinations to underpin risk management approaches to pathogen reduction in meats;
- Effect of chilling rates of hot/warm-boned meat on the spoilage, especially blown pack spoilage and assessment of the safety risks associated with spoilage;
- Preservation systems to improve shelf life and facilitate access to new markets via longer distribution chains whilst maintaining quality and safety;
- Development of rapid methods for the identification of microbiological contamination.

Chemical contaminants encompasses a broad range of substances such as veterinary drugs, feed additives, growth promoting agents, pesticides, natural toxins (incl. marine) and persistent organic pollutants present in the environment. These substances have the potential to contaminate food, impact negatively on food trade and damage Ireland's international reputation. In addition, the National Food Residue Database (NFRD) and the National Food Consumption databases are invaluable tools that should be further exploited for the benefit of the food industry, public health and regulatory authorities.

Research Objectives:

- Prediction and monitoring of the behaviour and fate of relevant known and emerging chemical hazards including toxins of biological origin;
- Development and validation of analytical methods including multi-residue veterinary drug analytical methods;
- Development of 'real time' analytical test kits for use in industrial settings to use in verification of HACCP systems;
- Exploitation of the existing databases of food consumption and related databases for the purpose of probabilistic modeling of human exposure to chemical contaminants;
- Databases of food consumption and related databases need to be updated on a regular basis to ensure the currency of the data for addressing food safety issues related to food chemical exposure.

Quality, traceability and authenticity - consumers increasingly seek guarantees of quality, traceability, authenticity and safety from the point of purchase and to consumption. For example, there is presently no incentive for farmers to produce meat which meets the consumer's requirement for sensory or nutritional quality (flavour, tenderness,

marbling, fatty acid profile and conjugated linoleic acid (CLA) content). Addressing this issue requires food scientists, animal scientists (breeding/genetics expertise) and the food industry to engage in collaborative research. Food Harvest 2020 clearly identifies the need to provide all consumers with guarantees of provenance/authenticity. Supporting this goal requires research which addresses challenges identified by the industry and the concerns of all food consumers for such guarantees of overall quality.

Research Objectives:

- Support research involving animal production through to food science with a focus on animal/plant breeding/genetics³¹;
- Support the development of analytical capabilities focused on food provenance/authenticity and traceability by harnessing the current expertise through collaborative research to avoid any duplication of effort or technologies;
- Enhancement of product quality through animal/plant breeding and processing practices;
- Support research that can provide tools to monitor and validate the quality and safety of the primary assets underpinning the food industry.

³¹ The research objective should be addressed in a joint RSF/FIRM research initiative

CHAPTER FIVE: REALISING FOOD RESEARCH IRELAND- IMPLEMENTATION AND MEASURING SUCCESS



Department of
**Agriculture,
Food and the Marine**
An Roinn
**Talmhaíochta,
Bia agus Mara**

5.1 IMPLEMENTATION

The implementation of the research objectives set out under each of the key investment areas in the plan will need to be considered in light of the following:

- Food Harvest 2020
- Report of the National Research Prioritisation Exercise and any action plans arising from that exercise
- National recovery Plan 2011 - 2014
- Availability of national and international funds for research
- Joint European activities including joint programming and the European Research Area
- National and European policy (e.g. National IP Policy)

It should be noted that the thematic research areas, the key investment areas or the research objectives have not been prioritised within *Food Research Ireland*. An action plan will be developed and should be considerate of any outputs of the Research Prioritisation Exercise and of the strategic needs of the various stakeholders. It is clear, however, that implementation of *Food Research Ireland* will require ongoing interaction with various stakeholders; the building of new and strengthening of existing collaborations between industry and academia, between institutions, nationally and internationally and between funding initiatives of Government Departments and funding agencies.

It is expected that the research objectives will be translated in to research instruments / activities to be delivered within a specified time frame. However, it is recognised that some research objectives are more long-term than others. Therefore, the time horizons for the delivery of *Food Research Ireland* should be clearly set out in any action plan. Value for money indicators and other metrics of success should also be considered.

5.1.1 STAKEHOLDER INVOLVEMENT

Food Research Ireland has brought together, for the first time, all major stakeholders who have identified their research needs and who can benefit from the outputs of publicly funded food research. The research objectives have been informed by the needs of both the consumer and the food industry; and will enable the industry to deliver on the ambitious targets set out in Food Harvest 2020 through the exploitation of the existing research capacity and critical mass. The successful delivery of this research plan will require ongoing consultation with these stakeholders; should be reflective of the needs of the food sector to 2020 whilst at the same time being cognisant of the ongoing need to support the development of the smart economy. It is recommended that stakeholders are consulted on an annual basis for further updating/feedback in relation to whether the specific objectives of *Food Research Ireland* as outlined in Chapter 3 are being met and the overall Vision is being realised.

It is proposed that the following activities could be considered in the implementation phase.

Table 5.1: Proposed engagement activities for stakeholders

Stakeholder	Engagement Activity	Key Performance Indicator
Government Departments/ regulatory authorities	Policy development underpinned by robust science	Scientific outputs disseminated to relevant policy makers to underpin policy development
State Agencies	Identification of stakeholder needs	Stakeholder insights and drivers identified and incorporated into research programmes
Funding Agencies	Joint funding initiatives	Joint funding initiatives launched
Industry	Industry involved in overarching Steering Committee of research programmes	Industry representatives actively participating in Steering Committees of Research Programmes
	Co-funding of research programmes	Co-funding from industry provided
	Public / private partnerships	New public/private partnerships funded
	Joint industry / academic appointments	Joint appointments made
	Mobility of researchers between industry and academia	Graduate / postgraduate placement programmes in place
	Networks involving industry and academia	Networks developed
	Access to research infrastructures	Research equipment accessed by industry
General Public	Information sessions / demonstration events	Public information sessions/events organized in areas of public interest

5.1.2 KNOWLEDGE AND TECHNOLOGY TRANSFER

In common with most industry sectors, Ireland's food sector faces obstacles in improving its innovation performance. Before companies reach the status of being serial innovators, the conditions for successful knowledge transfer have to exist. Various research measures have enabled the sector to enhance and develop its innovative capabilities. However, fundamental to enabling this is an effective technology transfer system which leads to higher levels of research outputs being commercialised. As is widely recognised, Ireland's track record in commercialising research outputs is only just developing and lessons need to be shared and successful experiences and models promoted.

In the last 5 years the Technology Transfer landscape in Ireland has changed substantially, providing a key element in supporting the commercialisation and level of industry engagement with the outputs of state funded research. In 2006, EI commenced a 5 year programme to strengthen the Technology Transfer system in Ireland, the objective of which is to increase the level and quality of Intellectual Property (IP) transferred from research in HEIs to industry and to facilitate the development of effective systems and policies to ensure that the IP is identified, protected and transferred to industry.

All HEIs in Ireland have been supported through this programme to date and key output performance indicators from the programme show a significant and sustained increase in licensing, industry collaborative research and start-up company generation activity over the baseline data prior to the commencement of the programme. In particular, the metrics show a high level of licensing activity with industry in Ireland. Comparisons with international statistics for technology transfer show that Ireland is currently performing as good if not better in some instances with more mature technology transfer systems worldwide.

In addition to the system in the HEI's, the Teagasc Food Technology Transfer Strategy, currently being finalised, contains a number of key actions to ensure that Teagasc's formidable food research outputs,

expertise and infrastructure are fully utilised and exploited for the benefit of the Irish food and agriculture industries. The Strategy involves systematic and structured technology interactions with Irish food companies with a particular focus on providing a support service for SMEs in collaboration with Enterprise Ireland. A proactive engagement with the food sector will be at the core of the strategy and Teagasc will ensure best practice in managing and measuring its food technology transfer activities. It will be committed to a number of principles including nurturing a culture of technology transfer and entrepreneurship as recommended by the Innovation Task Force in their report "Innovation Ireland"³².

The Irish Technology Transfer system is still young and developing. Following the reports of the Innovation Taskforce and the Forfas IP review³³ of the Technology Transfer system in 2010, an IP Implementation Group and an IP Policy Group were set up by the Department of Enterprise Jobs and Innovation. This work, currently in the final stages, will provide the platform for the future development of the academic-industry interface, to build on what has been achieved to date by further developing and releasing RPO knowledge for the economic and social benefit of Ireland and supporting RPOs to build and extend their capability to engage with users of knowledge in business.

Under SSTI, Government Departments and Agencies committed to significantly enhance the role of industry-academic collaboration as a vehicle for driving innovation and commercialisation in the economy. The essence of this effort was captured by the development of an industry-led research agenda and technology centres (previously known as competence centres) through which sectors could be supported in a strategic manner by setting the research agenda and linking to relevant research expertise in the RPOs to deliver on that agenda. The lead example of this initiative across all sectors was Food for Health Ireland, the large scale industry-academic research centre involving the dairy industry and 4 RPOs to mine milk for new health beneficial ingredients.

³² Innovation Ireland – Report of the Innovation Taskforce - March 2010

³³ Review of supports for exploitation of Intellectual Property from Higher education Research – April 2010. Published by Forfas

Other industry-Academic Collaborative Supports and Research Commercialisation Funds which can be key components in optimising the commercial and industry agenda from food research include Technology Centres and EI funded Industry-Led Research Programmes, Innovation Partnerships, Innovation Vouchers, Applied Research Enhancement and Commercialisation Fund. In addition, FIRM Plus³⁴ is aligned with the above programmes to ensure that publicly funded FIRM research which has commercial potential can be developed along an optimal commercialisation path.

Overall, the investments in research, development and innovation (RDI) must be deployed to deliver strategic value for the sector across the following asset bases:

■ Pipeline (of technologies)

Upstream, the pipeline of technologies for the food companies to exploit must be deepened and broadened so as to ensure an adequate number of commercial opportunities are developed and exploited.

■ People (investment)

Investment in upskilling and widening the available pool of RDI staff available to work in food companies and to work in supporting the transfer of technology into companies will be made. Unless this issue is addressed, the investment upstream in technologies and in platforms downstream will continue to have limited uptake by food companies.

■ Platform (of strategic investments)

In the medium to long term, industry focused and led R&D programmes must be identified and funded so that strategic investments are made to future proof the sector where most impact can be made.

Together, the relevant Government Departments and development agencies and industry are creating a national policy framework and tools within which companies can access and utilise new and known technologies that will ultimately support them to develop their businesses and exploit new opportunities and markets in to the future.

5.1.3 COLLABORATION

Having developed strong collaborative links with other funding agencies through the development of *Food Research Ireland*, these links need to be maintained and indeed strengthened through a continuous feedback mechanism to ensure the outputs of the research are exploited by the relevant end-users. Collaboration may be pursued at a number of levels. At the *National* level, government investments in science, technology and innovation have led to a strong research base and critical mass within and between many Irish RPO's across all areas of research. To ensure that the industry can deliver on the export growth targets in *Food Harvest 2020*, there is a need to continue to strengthen this research base and the links between it and industry to ensure maximum exploitation of the research outputs through either direct technology transfer or knowledge transfer (i.e. scale-up followed by full commercialisation of processes / technologies). Collaboration may involve intra- and inter-institutional partnerships, public/private partnerships or other mechanisms that are deemed appropriate. It should be remembered that the same collaboration model may not be applicable nor relevant for each of the sectors within the food industry. *Internationally*, collaboration with different jurisdictions should be encouraged and facilitated to ensure maximum value is gained from any investments made. There are many benefits of collaborating with those outside of Ireland, including the avoidance of duplication of the research effort and the sharing of resources particularly in those research areas associated with grand societal challenges. Indeed, international collaboration is the way forward and is one of the key strengths of Joint Programming mentioned previously.

³⁴ FIRM Plus – a new initiative launched under the DAFM Competitive Call 2010 that aimed to add value with a view commercialising research outputs previously generated from FIRM funded research projects

An important output of funding research through national research programmes is the ability to internationalise our national research capacity. Researchers who have developed competency under national funding programmes are expected to continuously engage with international consortia and leverage additional funding to augment their research activities. However, Ireland must continue to identify opportunities for further international collaboration with regard to food research. In doing so, Ireland can leverage additional resources that will not only strengthen the national capacity but will also ensure that our research is not only in line with international standards but in some cases can lead the international science.

North South co-operation – there is significant political-will in both parts of the island to advance collaboration with regard to funding research, however, at funding body level engagement is poor. As an initial phase it may be appropriate to develop key collaborations in certain mutually agreed priority areas in order to develop the processes and methodologies for further collaboration on an ongoing basis. The fact that Ireland adopts an all island approach to FP7 could be used as sound rationale for such a joined up strategy. In order to make such an arrangement it is important that contacts are established at a high level. Currently, DAFM, through their competitive research programmes have funded research consortia which include partners from RPO's in Northern Ireland. In addition, Safefood consistently funds projects on an all-island basis. It is important to develop further the North-South collaboration in research.

International Agreements - DAFM already have experience of such international agreements through its Memoranda of Understanding (MOU) in food research with the USDA and the FDA. Consideration should be given to entering into discussions with other significant

international research players with a view, possibly, to agreeing other MOU's. This could be achieved by DAFM re-examining the relationship with USDA and FDA and look to develop further mutually beneficial relationships. To date there has been some engagement with Finland and The Netherlands which merit further consideration. As a starting point, research agreements between Irish RPO's and their international counterparts should be examined to determine the most appropriate countries with whom we should co-operate. European Research Area Networks (ERANETs) and other EU programmes could provide the opportunity for developing such cross border relationships.

International Research Funding - The successful implementation of *Food Research Ireland* requires excellent research and excellent researchers. The EU's 7th Framework Programme³⁵ offers Irish researchers the opportunity to work with and be the best in Europe and to showcase our research excellence.

Ireland's involvement in international research is a central component in the development of a knowledge economy. Over the course of the past 10 years there has been considerable investment by the Irish Government in building national research capacity, capability and critical mass. Our stated objectives of internationalisation and the importance of collaboration with other researchers outside of Ireland will require researchers who have attracted considerable national investment to advance and develop international research collaborations. Indeed, many Irish researchers have been successful in attracting international funds from the EU Framework Programme, National Institute of Health in the USA and others. However, additional funds can be leveraged.

³⁵ The Seventh EU Framework Programme (FP7) for research and technological development is the European Union's main instrument for funding research in Europe. The programme is set to run from 2007 to 2013 and has a budget of €53.2bn over its seven-year lifespan with €1.9bn dedicated to research in the food, agricultural, fisheries and biotechnological theme area. FP7 has 4 main elements: Cooperation; Ideas; People and Capacities. Further details are available on www.fp7ireland.com. Irish researchers in the agri-food sector focus mainly on Cooperation Theme 2: 'Food, Agriculture and Fisheries, and Biotechnology' (FAFB) for funding. This theme is built around three major activities:

- Sustainable production and management of biological resources from land, forest and aquatic environments;
- Fork to farm: Food (including seafood), health and well-being;
- Life sciences, biotechnology and biochemistry for sustainable non-food products and processes.

Although FP7 is the largest funding programme in Europe, it is a fraction (estimated to be 5%) of the total spend on research across the EU. The majority of money committed to research is through national programmes, which can result in duplicity of effort and inefficiencies in problem solving. With this in mind the research strategy within the EU is changing direction with more emphasis now being placed on coordinated transnational cooperation. ERANETs³⁶ and Joint Programming have the objective to step up the cooperation and coordination of research activities carried out at national or regional level in the Member States and Associated States through the networking of research activities, and the mutual opening of national and regional research programmes. In the coming years, it is important that efforts continue to ensure an increase in the amount of funding coming in to Ireland through FP7 and its successor “Horizon 2020”.

5.2 MEASURING SUCCESS

Food Research Ireland will act as a roadmap for future competitive funding of food research activities. It is intended to guide state investments up to 2020. To ensure that it remains relevant to the needs of stakeholders, it is recommended that the roadmap be reviewed annually and in line with funding initiatives to ensure that the investments being made are reflective of the research objectives outlined herein. In addition to a review of the roadmap, it is envisaged that the research activities funded will be reviewed at a high level by the Food Research Expert Advisory Group or other relevant stakeholder groups. Evaluation of research proposals and post award monitoring of research initiatives will be the responsibility of the lead funding agency or as agreed within a cob-funded initiative and/or in accordance with the terms and conditions of the award.

5.2.1 BENCHMARKING OF R&D PERFORMANCE AND INVESTMENT

As part of contextualising the implementation of *Food Research Ireland*, particularly in identifying priorities for national investment, a benchmarking analysis of the current R&D performance of the food sector should be carried out. This should enable an assessment of the R&D performance of the Irish food sector as a whole, within industry and within the research base and allow relevant benchmarks with best international practice to inform the priorities and targets for support.

Food Harvest 2020, referencing international benchmarks, calls for a doubling of industry investment in R&D to 2020 (R&D as percentage of turnover) from a cross sectoral average of 0.65% to 1.3%. As previously mentioned, the current measure of Business Expenditure on R&D (BERD) performance (0.65%) is significantly below accepted industry standards with best in class operating at approximately 2.5 % (UK Department of Trade and Industry Annual R&D Scorecard). In addition, and as mentioned previously, increased collaboration between industry and academia will be required to ensure that the research is informed by and exploited by the needs of the industry. If this step change is to be met, it will be important to ensure that current performance of all stakeholders in *Food Research Ireland* are assessed, compared with relevant international R&D benchmarks and initiatives and used to guide the priorities that will underpin *Food Research Ireland* to best support the food sector as a whole to realise Food Harvest 2020 targets.

³⁶ ERA-NET actions provide a framework for actors implementing public research programmes to coordinate their activities and reduce the fragmentation of the European Research Area

5.2.2 MEASURING RETURNS ON STATE SUPPORTED R&D

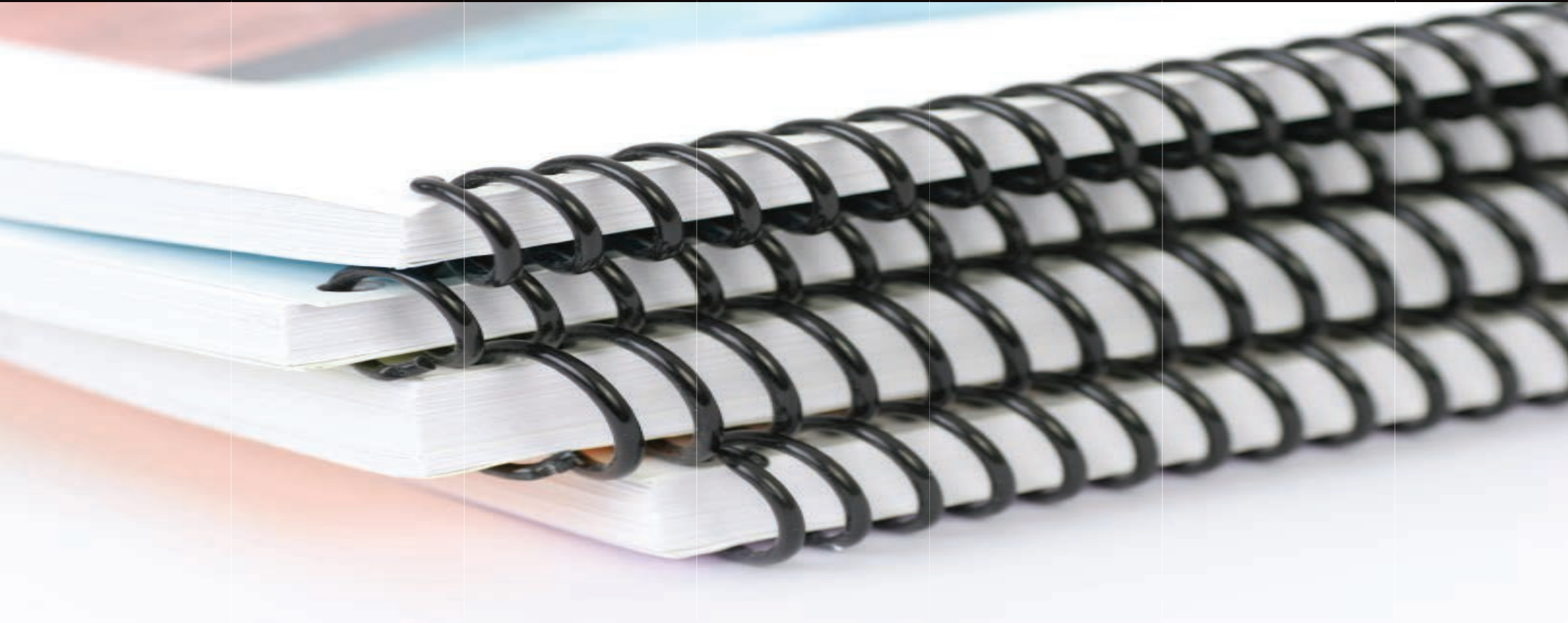
The Innovation taskforce recommended that *“a study should be undertaken to identify a model for measuring direct and indirect economic returns from public investment in R&D in Ireland to inform decision-making on investment priorities and refine the framework of performance indicators for science, technology and innovation investments”*.

The Taskforce recognises that measuring the impact of state investment in R&D is not without its difficulties. The metrics used range from publications, patents, and people to the number and value of academic collaborations, the average number of years of industry experience which academics have obtained during their careers, the number of new products developed and the number of innovations adopted by industry etc. Notwithstanding the difficulties of capturing both the relevant and appropriate quantitative and qualitative data, it would be important for any action plan to develop metrics that are meaningful to the stakeholders involved and to develop a process by which these metrics are evaluated. However, it may be prudent to await the action plans developed from the National Research Prioritisation Study before finalizing the metrics for *Food Research Ireland*.

5.3 CONCLUDING REMARK

To ensure success, it is vital that investments made in delivering on the research objectives of *Food Research Ireland* are fully aligned and utilise the structures and instruments above to ensure optimal commercialisation and industry benefit from the State’s investment in food research.

APPENDICES



APPENDIX 1

IRISH FOOD RESEARCH INFRASTRUCTURE

GOVERNMENT LABORATORIES

DAFM - the DAFM serves a dual role, operating both as a funder of research in food (through the Grant-in-Aid to both Teagasc and the Marine Institute and operation of its competitive research funding programmes³⁷) and a research performer within the state-of-the-art laboratory facilities at Backweston. These laboratories, completed in 2005, provide DAFM with the opportunity not only to strengthen the regulatory control support work of the various Divisions (e.g. Pesticides, Bacteriology, Virology, Meat Control, Veterinary, Seed Testing, Plant Health, etc.) but also to develop research capability to aid in the control and policy aspects of these Divisions. Currently, there is ongoing collaboration between the laboratories and the research community, particularly in the area of food safety. DAFM also provide the National Contact Point and the National Delegate for the EU Framework Programme Agriculture, Food, Fisheries and Biotechnology Theme.

STATE AGENCIES

Teagasc was established under the Agriculture (Research, Training and Advice) Act 1988. Its mission is to provide science-based innovation support to the agriculture and food sectors. At Teagasc research centres located throughout Ireland, over 750 scientific researchers, technical staff and postgraduate students are working on innovative and cutting-edge projects related food and agriculture.

Teagasc has very close links with the food industry with which it engages in a variety of technology transfer activities including dissemination, contract research, technology licensing and technical services. These have been strengthened recently by the development of an SME technology transfer service.

The Marine Institute (MI) undertakes, co-ordinates, promotes and assists in marine research and development including marine food research. As the lead implementing agency for Sea Change – A Marine Knowledge, Research & Innovation Strategy for Ireland 2007-2013, the Marine Institute co-ordinates and promotes marine research, bringing together industry, higher education institutions and government bodies to support the development of Ireland’s knowledge economy. The Marine Institute also provides advice for marine researchers who wish to investigate opportunities for international funding under specific open calls.

On behalf of the DAFM, MI administers the Marine Research Sub-Programme of the National Development Plan 2007-2013 via competitive calls for research projects which support existing marine food sectors e.g. fisheries and aquaculture, and exploitation of marine resources for other uses e.g. functional foods, pharmaceuticals, cosmetics etc. In addition, MI undertakes research (both applied and experimental development) alongside its operational programmes (e.g. in the areas of fish health, food safety, fisheries science, climate change, oceanography, knowledge and information management, environmental, catchment management) and also through leading and participating in many national and international research projects.

³⁷ **Food Institutional Research Measure (FIRM)** - This measure has been in operation since 2000, and is the main programme for funding of food research in public research institutions in Ireland. The programme has funded 239 projects to date to the value of circa. €140m. The aim of FIRM is to develop public good technologies that will underpin a competitive, innovative and sustainable food manufacturing and marketing sector.

Research Stimulus Fund (RSF) - Agriculture research is supported under the Research Stimulus Fund. The main aim of the programme is to create knowledge that will enable Irish agriculture to become a vibrant, competitive industry with improved productivity that is also environmentally sustainable. The programme has been at the forefront in developing core expertise in agriculture research within both Teagasc, the Higher Education Institute Network in Ireland, North and South. The programme has funded 113 projects to date to the value of circa. €48m.

Programme of Competitive Forestry Research for Development (COFORD) - The COFORD programme is the primary source of forest research funding in Ireland. The aim of the programme is to create knowledge and capability in the public research institutions to help inform policy development and also to underpin the forest sector thereby enabling it to play a full part in the development of the national economy.

The MI is the National Reference Laboratory (NRL) for several marine contaminants including veterinary drug residues in fish and marine biotoxins in marine shellfish. The Institute is also the NRL for monitoring bacterial and viral contamination of bivalve molluscan shellfish. The NRL is responsible for providing advice, ensuring the relevant EU legislation is operated and co-ordinating the activities of national laboratories involved in the monitoring of shellfish harvesting areas for biotoxin concentrations and classification purposes. In accordance with various EU legislation, monitoring of shellfish, farmed finfish and fish landed at Irish ports is carried out by the MI to ensure concentrations of environmental contaminants such as mercury, cadmium and lead and persistent organic pollutants are within safe limits for consumers. The MI carries out these monitoring programmes in conjunction with the FSAI and the Sea Fisheries Protection Authority (SFPA) and provides scientific advice to government, industry and the general public on seafood safety matters.

Bord Bia is the Irish State agency with responsibility for the marketing and promotion of Irish food and drink products globally. As part of its remit, Bord Bia actively engages in both consumer and trade related research programmes aimed at equipping Irish exporters with the necessary insights to secure new business and enhance existing relationships.

Through its Insight and Innovation team, Bord Bia delivers research programmes such as Consumer Lifestyle Trends and Periscope that ensure Irish exporters have clear insights into how consumer needs are evolving. In tandem with this, the foresight4food programme works with companies individually to develop new product concepts, test them in the marketplace and assist with bringing them to launch. Trade research focuses on identifying new market opportunities for exports. Examples of recent research projects in this area include customer strategies in relation to Sustainability and emerging market opportunities for Irish dairy ingredients.

Bord Iascaigh Mhara (BIM) is the State agency with responsibility for the sustainable development of the Irish Seafood industry. It provides a range of services including advisory, financial, technical, and training supports to all sectors of the industry.

BIM's Business Development and Innovation Division provides support to seafood processing companies with the objective of increasing profitability through maximising economies of scale and implementation of lean manufacturing practice and technology. Through its programmes participating companies receive assistance in applying innovation to their business strategies.

BIM's Seafood Development Centre (SDC) is a dedicated innovation facility for the Irish seafood sector. The SDC enables companies with a feasible business strategy to apply research and innovative technologies to the development of value added products; thus ensuring that product offerings keep pace with changing consumer preference in the domestic and export markets.

HIGHER EDUCATION INSTITUTES:

There are seven **Universities** in Ireland; National Universities of Ireland Dublin, Cork, Galway and Maynooth plus University of Limerick, Trinity College Dublin, and Dublin City University. Collectively, under the Irish Universities Association, their aim is to develop and sustain a dynamic research environment. The seven universities pursue a common strategic policy and collaborate in research efforts. They offer state-of-the-art postgraduate level training through a broad range of taught courses and research. These universities are central in 'ensuring Ireland continues to advance and becomes a fully-fledged knowledge society. The university network is supported by the Department of Education & Skills block grant and most have also benefited from the HEA PRTLII programme to undertake successive capital investment projects. All are involved, to a greater or lesser extent, in food research.

There are **13 Institutes of Technology (IoT's)** in Ireland. Although historically not as actively involved (owing to a heavier lecture load), research now forms a core component of each of the institutes. The IoTs' play an integral role in creating Ireland's postgraduate research community. They are particularly effective at pre-commercial research and have strong links with industry. Some are more active/relevant than others to the food sector e.g. Waterford, Cork, Carlow, Galway, Mayo, Letterkenny, Dublin, Sligo and Tralee.

In order to facilitate change and embrace an internationally accepted model on infrastructure for research, many of the principal research bodies have embarked on a number of measures to enhance their research and development capacity.

A key component of this infrastructural change has been the development of highly specialised research units within the principal institutions by concentrating existing capacity and resources. These highly equipped research groups/units have rapidly earned international recognition for excellence in research and have attracted international expertise and are providing training for under- and post-graduate students to a level unattainable in the past. Other key measures in the infrastructural reformation has been the willingness to adopt both an intra- and inter-institutional collaborative approach, recognising past strengths of specific institutions, and allowing them to champion ad hoc research programmes on a collaborative basis. These activities have provided a base of expertise for R&D to be undertaken by industry either within company or in collaboration with the research institutions in Ireland.

IRISH FOOD RESEARCH STRENGTHS

FOOD PROCESSING TECHNOLOGIES

Irish research institutions have significant research expertise in processing technologies which can be accessed by all sectors of the food industry including, dairy including infant formula, meat, cereals, fish and shellfish, fresh-cut produce and beverages.

DAIRY Process Design and Control is ongoing in a number of centres in Ireland. Considerable research has been conducted in the area of dairy powder technology, in particular optimisation of the spray-drying process, controlling powder stickiness and in developing ingredients with characteristics suitable for a variety of processing conditions, e.g. heat stable, flowable etc. Research is also being carried out in the area of applications of high pressure and on-line sensors for dairy products. The use of high pressure processing in meat has also been explored.

Non-thermal process technologies including ultrasound (US); high intensity light pulses (HILP); ultraviolet light (UV) and high voltage pulsed electrical fields (PEF) to provide more gentle process technologies to preserve and extend the shelf-life of beverages and ozone are also being investigated. Extraction technologies are also being developed. These technologies may also be applied to meat products.

Cereal process technology focuses on optimisation of formulations and processes for novel product development, some of which include extrusion, fluidised bed and high shear. New healthy snack food products are being developed from cereals for elderly consumers.

Research is ongoing on technology optimisation to minimise losses of vitamins and minerals from fresh-cut fruits and vegetables. Antioxidant status in processed fruits and vegetables is also being investigated. A Hyperspectral Imaging System for the non-destructive assessment of mushroom quality and shelf life prediction and technologies to identify sub-standard batches of mushrooms are also the focus of Irish researchers.

Research expertise in packaging technologies is also available including PACK-in-MAP, a web-based software tool to help companies optimise modified atmosphere packaging (MAP) for fresh and fresh-cut fruits and vegetables. The optimised packaging solution can recommend the most cost effective packaging material, gas atmosphere and temperature conditions to extend shelf life, quality and safety of fresh-cut produce.

Researchers have also worked to optimise packaging solutions to extend the shelf life and improve the microbial safety of foods. The technologies include MAP, vacuum pac, active and smart packing solutions as well as edible films. Work is ongoing on the development of smart packaging solutions to enhance the quality, safety and shelf-life of beverages and foods, the aim is to incorporate antimicrobial/ antibacterial nanoparticles into conventional packaging materials to develop active antibacterial packaging systems and also to develop cob2 sensors for inclusion in MAP foods. They will evaluate these technologies alone and in combination to devise the optimum packaging solutions for different foods and beverages. A software model has been developed to optimise packaging solutions for fresh and fresh-cut fruits and vegetables (www.packinmap.com). Research expertise on the control of blown pack spoilage in vacuum packaged beef and active packaging systems for enhanced quality, safety and shelf life of exported fresh beef is also available.

FOOD SCIENCE AND INNOVATION

Ireland has significant research expertise in all of the major industry sectors including dairy, meat, beverages, cereals, seafoods and fresh-cut produce.

Dairy: Researchers are currently developing processes to manufacture cost-effective ingredient cheeses and concentrated cheese flavours (enzyme modified cheese). The ingredient cheeses will be rapidly ripened, have a range of different flavours and will be capable of being produced in Cheddar cheese plants. Methods to enhance the flavour and accelerate the ripening of Cheddar cheese using milk pre-treatments as well as enzymology and microfluidisation technologies have been developed. And novel cheese-based snacks with enhanced texture and functional properties have been produced.

Irish researchers are renowned in the field of dairy ingredient development, in particular the isolation, characterisation, separation and enrichment of dairy-based ingredients, e.g. proteinates, caseins etc. Researchers are working to provide whey protein manufactures with new insights as to how to optimise the processing of α -lactalbumin containing ingredients; on replacing proteins with lower cost ingredients such as starch and combining proteins and carbohydrates in novel ways to produce products that can control blood sugar levels. New knowledge is being generated in the area of food nano-technology through the National Food Imaging Centre based in Teagasc. The Centre is currently studying the molecular self-assembly of whey proteins and to date, the conditions have been optimised for production of whey protein nano-fibres and they are currently characterising their functional properties and digestibility. Under the auspices of the Cork Bacteriocin Group, work has been ongoing for many years to develop dairy-based biopreservatives, e.g. lacticin 3147 and have numerous patents have been lodged in this area. Work is ongoing in the area of dairy powders, specifically on the development of tests which showed that hydrolysates of whey proteins have improved efficacy to inhibit pathogen adhesion. Another research group is investigating novel enzymatic and processing strategies to generate casein hydrolysates with reduced bitterness and antigenic potential.

Other research expertise includes the development of bioactive ingredients, such as oligosaccharides, lactoferrin, α -lactalbumin, β -lactoglobulin. A bioassay to validate in-vitro nutritional claims, e.g. anti-cancer, anti-microbial, ACE inhibitory, has been perfected. In-vivo facilities and expertise are also available. And Irish researchers have recently proven that conjugated linoleic acid (CLA) can be efficiently produced by selected bacteria, enhanced in milk by feeding sunflower oil as part of the cows diet and has the potential to reduce growth of cancer cells, thus aiding the reduction of some cancer tumours.

Using advanced proteomics techniques, researchers have developed a more fundamental understanding of many aspects of milk proteins. A rapid and cost effective method to assess the relative bioavailability of vitamins has been developed, e.g. α -tocopherol (vit E) and retinol (vit A) in meat, dairy products and fortified fruit juice.

Researchers with expertise in mining milk for bioactive ingredients are working with marine biological scientists to identify bioactive ingredients from seaweeds, micro-algae, fish – including, shellfish and from fish processing waste streams. Particular expertise exists in identifying peptides, enzymes, polymers, lipids and protein hydrolysates and materials possessing anti-oxidant, probiotic and prebiotic properties from marine species.

Microcapsules (microgels) from marine polysaccharides, e.g. seaweed and alginates which are used to encapsulate materials such as food ingredients and are designed to release their contents at a certain destination either within the food product or human body where the beneficial effects can be realized have been developed. When added to foods the microgels do not affect their quality or texture and act as vehicles to enhance their flavour and nutritional properties.

Research on extracellular polysaccharide (EPS) and its association with lactic acid bacteria with a view to establishing their functionality in dairy and cereal-based products is ongoing.

Beverage technological development supports two distinct sectors i.e. alcoholic and non-alcoholic beverages. Irish scientists are uniquely positioned through years of research to help beverage companies (alcoholic and non-alcoholic) improve the efficiency of production processes, characterise existing products and/or develop new beverages based on novel concepts or added functional ingredients. They have considerable expertise in brewing & malting technology, beverage formulation, process technology and product development.

Research expertise is available in brewing beer with yeast that produces an anti-microbial peptide (AMP) to kill beer-spoiling microbes, a technology aimed at helping to improve the shelf life of beer and innovative ways of eliminating beer spoilage, caused by beer spoiling microbes is being investigated. Human defensins that can kill beer spoiling microbes without affecting the yeast that ferments the beer have been identified. This technology will be a step towards improving the shelf-life of beer.

In the area of **meat**, technologies for improved efficiencies and enhanced product quality, e.g. Tenderbound™ (hot boning and PiVac), electrical stimulation etc. have been developed and researchers are also working on methods to investigate the structural, biochemical and molecular basis for variation in quality. A patent has been filed which identifies the organisms that cause blown pack spoilage (major cause of loss); this test is currently being supplied as a service to industry. Work has been completed on DNA markers for meat quality traits, use of genetics to predict meat quality and the interaction of gene expression, breed and diet on the nutritive and flavour aspects of meat. Research is also ongoing to examine and explain the effects of ingredient addition and processing interventions on meat product structure and function. The functional peptides in beef, offal and fermented beef products are being investigated and this research could add value to these meats.

The application of high voltage pulsed electric fields (PEF) and high intensity ultrasound (US) to beef and ham products to assess if they can speed up tenderisation and curing is being investigated. Work has recently been completed in the area of electroheat applications for meat processing and radio frequency heating. Isotopes are being used to predict the geographical origin of meat, its rearing system and the diet history of animals. So far data is showing that stable isotope ratio analysis is a powerful tool in meat authentication. The health benefits of high CLA beef are being investigated. Research expertise also exists in computer vision systems based on image analysis which could be used as a rapid,

consistent, accurate, objective and economical tool to test the quality of pre-sliced cooked pork and turkey hams. Methods have also been developed to authenticate the geographical origin of meat and a tracking system has been generated for the red meat and poultry sectors.

The possibility of exploiting eggs, meat and its by-products as novel sources of the major metabolite of vitamin D is currently being researched. Researchers have completed work on identifying specific pig genes associated with meat quality.

Research at UCC and Teagasc delivers a wide range of food and health solutions for the **cereal and bakery industries**. The scientists identify suitable ingredients, study enzyme interactions and formulate healthy products with desired flavour, texture and quality that are nutritionally appealing to the consumer. They have collaborated to develop gluten-free baked goods and beers, breads with low-glycaemic index, reduced salt etc. Considerable experience in production of sourdough and par-baked goods is also available. Both groups also work to optimise the physical and chemical properties of flour, dough and breads. DIT houses the National Bakery School and specialise in product formulation, baking, pastry and extrusion technology.

The **fresh and fresh cut produce** researchers at Teagasc, UL and DIT combine a multidisciplinary group of researchers involved in cultivation, processing, storage optimisation, bioactive discovery and authentication of cereals, fruits and vegetables. UL have put significant resources into process optimisation and the microbial safety of fresh produce.

Teagasc are involved in exploring the health promoting properties of fruits and vegetables, e.g. polyacetylenes, the potential of waste potato skins as a source of glycoalkaloids and bioactive peptides. UCC is investigating the functional benefits of plant sterols and stanols as ingredients in functional foods, recent results show that plant

sterols/stanols are non-toxic compounds, do not interfere with the absorption of fat soluble nutrients and show positive effects on the immune system. UCC have also developed a software system (www.packinmap.com) to optimise packing solutions for this sector.

DIT has research on novel approaches to extend and control the shelf life and maintain nutrient quality as well as investigating the potential of hyperspectral imaging for monitoring the quality of mushrooms.

In 2007, a phytochemical research network of Irish experts was funded by the DAFM to collate scientific expertise on phytochemicals found in Irish grown fruits and vegetables. The network, led by Teagasc, brings together existing knowledge and generates new information ensuring maximum benefit is derived from the collective expertise. The research of the Network will focus on examining agronomic factors (e.g., soil type, seasonal variation) fruits and vegetables, levels of phytochemicals in selected vegetables, effects of processing and storage as well as developing an understanding of consumer attitudes to phytochemicals. Teagasc are co-ordinators of the 'integrated photochemical network' which involves researchers from Teagasc, UCC, NUIG and DIT (<http://www.ipfn.ie/>).

FOOD AND HEALTH

Ireland has internationally recognised research expertise and capacity in many of the underpinning scientific areas related to food and health. Through sustained investment by Government and other funding agencies, the Irish food sector and Irish policy makers have access to the most up-to-date robust scientific knowledge in the area of nutrition, food consumption patterns, chemical and microbial residues in foods, food supplements, reformulation of foods to reduce salt, new ingredients for enhanced health from a variety of sources including dairy and marine and a deeper understanding of the influence of gut microflora on health.

Over the last decade, institutional research has been vibrant in this priority area. DAFM have funded in the region of 71 projects addressing food for health and nutrition; as well as co-funded four programmes with the Health Research Board under the Food and Health Research Initiative. This funding has led to expertise, capability and facilities that have delivered functional ingredients and foods as well as techniques to validate nutritional claims in vitro and in vivo. Irish scientists are leading Europe in the development of food consumption and lifestyle databases; these resources are of national importance to policy makers and the food industry in providing a platform for a national strategy for health and wellness. Interpreting these data is the job of our nutritional scientists. Together with the agencies and the food industry they have identified key areas of importance to the health of the population e.g. salt reduction, fortification of food with folic acid, vitamin D etc. FIRM have invested significant resources in the area of food and health for over 15 years and the capability generated has led to collaborative funding with the Health Research Board, the Marine Institute and more industry-focused funding from other agencies, e.g. Enterprise Ireland.

FOOD BUSINESS AND CONSUMER SCIENCE

Insights into **consumers' behaviour** and attitudes are key areas of expertise for Irish researchers who generate knowledge on consumers' wants, needs and perceptions, which are useful in developing and marketing new products and in assessing consumer and industry acceptability of novel food technologies. Understanding the market and consumer, supports new product development, innovation management, strategic market planning, marketing channels, and relationship management.

New product development involves a number of areas of expertise including retail, branding, modelling business processes, process innovation and innovation management and understanding the consumer. Irish researchers have worked directly with food companies to identify new market opportunities.

Risk perception is the subjective judgment that people make about the characteristics and severity of a risk, for example a food safety scare or the introduction of a novel technology (high pressure processing). Researchers have worked together to understand how and why consumers perceive risk and have developed successful communication strategies. In addition, an online survey called *Longitudinal Monitor of Food Risk Perception* was set up to monitor the perceptions, attitudes and behaviour of Irish people to a variety of food risks.

Food business researchers work extensively on the dynamics of **food supply chains** for the benefit of stakeholders; and on understanding retail activity, trends and performance. **Food economics** and the impact of national and international regulation and **policy** on the agriculture and food industry is also a focus of Irish researchers.

FOOD SAFETY

A wide variety of research is undertaken in the identification, detection and control of food-borne pathogens and spoilage organisms. Researchers within the Centre for Food Safety have expertise in many areas including detection and surveillance of *Enterobacter sakazaki*, *Campylobacter*, *Salmonella*, *Yersinia enterocolitica*, *Escherichia coli*, *Toxoplasma gondii*, microbial quantitative risk assessment, microbial genomics and bioinformatics. The UCD Centre for Food Safety is the designated World Health Organisation (WHO) Collaborating Centre for Research, Reference and Training on *Cronobacter*. The Centre for Food-borne Zoonomics (CFZ) (www.cfz.ie), was established in 2007 and is led by a group of food safety experts. These scientists are working closely with the food industry and regulatory agencies to reduce the incidences of food-borne poisoning associated with Gram negative pathogens, including *Salmonella* and VTEC. The research focuses on the genomic and proteomic responses by pathogens to stress. The network is a collaborative research effort between a number of research institutions and the DAFM laboratories.

Food-borne viruses have been characterised and mechanisms to determine the virulence characteristics of many pathogens and viruses have been defined. New assays to rapidly and cost effectively monitor the growth of food spoilage and pathogenic organisms are being developed. The *lux* (based on a principle of light emission) technology has been previously proven to track infectious organisms and is now being developed as a tool to assure food safety. Novel rapid testing kits for *Salmonella* which reduce the time of testing from 4 days to less than 2 days have been developed and these new tests have been validated against the standard ISO 6579 cultural method and provide a more rapid, equally sensitive and specific detection of *Salmonella* on meat, cheese and milk. Furthermore, the assays have the ability to specifically identify emerging multi-drug resistant serovars. The incidence and detection of mycotoxins in cereals have been extensively studied and work has recently been completed on assessing the ability of food spoilage- and food pathogenic- microbes to withstand stress, making them more able to survive in foods and drinks.

There is significant research expertise in the development of rapid testing methods to detect anti-parasitic drug residues in animal liver samples using a surface plasmon resonance (SPR) biosensor. A multi-residue confirmatory and screening method for the detection of veterinary drug and feed additive residues in foods of animal origin has also been developed. A rapid nucleic-acid based assay to measure gram positive and negative bacteria has also been developed. This method, based on a specific PCR detection method, has been validated against the gold standard method for meat and offers time and precision advantages to clients for microbiological assessment of perishable food products. Ireland also has research expertise in the detection, survival, prevalence and molecular characterisation of *Mycobacterium avium paratuberculosis* and rotavirus as well as the development of a real time PCR test for the detection of *Listeria monocytogenes* in foods.

Researchers are also examining the use of Fluorescent active cell sorting (FACS) for the rapid detection and enumeration of spoilage and pathogenic microorganisms in foods. This method could provide almost real time quality control data within a food processing environment, reduce product recalls and provide a greater level of assurance for the consumer.

The National Food Safety Database (NFSD) is a programme funded by DAFM under FIRM and the Department of Health and Children via the Health Research Board. This programme continues to develop Ireland's food safety infrastructure and builds on the existing National databases on residues, ingredients and supplements and biological contaminants. The NFSD will integrate and co-ordinate surveillance, research and expertise in the areas of chemical and biological contaminants as well as nutrition and health data to provide meaningful information for consumers, regulators and policy makers. Rapid detection methods for antibiotic residues in food have also been developed.

Irish researchers have expertise in the area of bio-preservation and shelf-life extension using food-derived bioactive ingredients to control and eliminate pathogenic and food spoilage microorganisms in ready-to-eat foods. New antifungal compounds from lactic acid bacteria (LAB) have also been identified and these could be used as natural preservatives for improved food safety and extended shelf-life. Marine sponges and other marine species are also being mined to discover new bioactive compounds with activity against food-borne pathogens. Pathogen inactivation is also an area in which Ireland has research capacity. Approaches investigated include bacteriocins, anti-microbial peptides and electrolysed water.

Many of the research organisations can provide scientific-based advice on strategies to reduce the pathogen load in food and beverages.

Research is also being supported in the area of Animal disease and its implication for the food chain. For example, a herd health programme to control Salmonella has been developed and transferred to DAFM veterinary surgeons. Methods to authenticate food of Irish origin, identify, track and trace animals along the supply chain, and methods to detect BSE/TSE are also areas of research within Irish research organisations.

Irish Researchers have developed risk management procedures for shellfisheries and examined the impact of waste water treatment plant effluent on norovirus contamination in shell-fisheries. The development of PCR methods for norovirus in shellfish has been used in managing outbreaks on a number of occasions and preventing illness in consumers. Shellfish are also prone to a number of naturally occurring toxins from phytoplankton sources, and research into these has resulted in novel and sensitive methods of detection by Liquid Chromatography-Mass Spectrometry (LCMS-MS). This is now the reference method adopted by the EU for the detection of lipophilic toxins. Irish research on one of these toxins, *Azaspic acid* and its esters, has resulted in extensive knowledge on its toxicity and toxicology, and the occurrence of its source organism in the phytoplankton. This toxin has been extracted and purified to certified standards, allowing it to be used as a reference material for research on the toxicity at cellular and within mammalian digestive systems. Research such as this has resulted in greater protection against seafood borne illness. Future research into forecasting of shellfish toxins is underway including the integration of monitoring data, in-situ data, satellite data, and modelled simulations to predict the occurrence of and mitigate their impact.

Antibiotic and biocide resistance is being investigated which seeks to understand how resistance to biocides develops in order to develop strategies to ensure such systems remain effective.

There is internationally recognised expertise in food risk assessment and consumer perception and studies have been undertaken to understand how consumers perceive risk over time and to develop effective strategies to communicate risk. In 2007, a food safety research network was set up and is undertaking quantitative risk assessment on *E. coli*, *Listeria*, *Salmonella* and *Cronobacter sakazakii* to underpin national risk management actions. The network includes food microbiologists, risk assessors, food safety communicators and economists who together will pool their resources to carry out quantitative risk assessment of Irish food from farm to fork.

Meat Industry Strategic Research Agenda

Thematic Areas	Key Investment Area	Potential areas for publicly funded research projects to address	Expected Impact
Food Innovation	Novel technologies	“There is a need to identify how process technologies and processing conditions alter ingredient interaction with food matrix”.	Input to new product development
Food Processing Technologies	Food Structures	“Understanding the science behind ingredient interactions to develop a structured approach to product formulation/ re-formulation with a view to developing improved healthy meat products”.	Input to new product development
		“Knowledge about the interaction of ingredients (salt, fat, proteins, hydrocolloids, phosphates, etc.) in various meat systems to enable a more structured approach to product development especially for targeted markets such as the elderly”.	Input to new product development
Food Innovation	Food Formulation	“Development of Functional Meat Products – the technology and know-how to produce new forms of traditional meat products and novel products with additional health benefits (nutraceuticals).”	Improvements in food and health
		“Project on functional peptide research”.	Product development
Food Safety & Quality	Food Safety & Quality	“Enhancement of beneficial fatty acids from grass based systems focusing on increasing conjugated linoleic acid in fresh meat and meat products”.	Value added products
		“The effect of chilling rates of hot/warm-boned meat on the spoilage, especially blown pack spoilage, and safety risks should be established and a new technology developed that will relate chilling/ other processing activities to spoilage/shelf-life and safety”.	Efficient manufacturing & enhanced safety and quality
Food Chain Integrity	Food Chain	“Recovering value from by-product streams, Integrity low value cuts and offals”	Added value products
Food Chain Sustainability	Food Chain Sustainability	“This R&D will minimise agricultural GHG emission in line with internationally agreed and binding limits. This R&D will reduce pathogen carriage in beef animals thereby protecting public health and the international markets for Irish beef.”	Reducing Greenhouse Gas emission during Beef Production
Food & Health	Nutrition	“The Research community can assist our sector in delivering solid science-based findings that provide positive messages on meat consumption, its fundamental role in the diet as well as its contribution to health and wellbeing.”	Food & Health

APPENDIX 2

INDUSTRY STRATEGIC RESEARCH AGENDAS

Dairy Research Agenda

Thematic Areas	Key Investment Area	Potential areas for publicly funded research projects to address	Expected Impact
Food processing technologies	Sensory Science	“Impact of technologies and formulations on the sensory attributes of the end product”	Product development
		“Relating chemistry of hydrolysates to sensory profiling”	Product development
		“Reduced fat/salt cheese with improved texture & flavour”	Product development
		“Low fat cheese texture improvements using hydrocolloids”	Product development
Food processing technologies	Encapsulation	“Novel encapsulation technologies”	Advanced processing technologies
		“Bioavailability”	Advanced processing technologies
		“Novel application in food matrices to mask flavour”	Advanced processing technologies
Food Innovation	Nanotechnology	Encapsulation technologies will exploit nanotechnology	Advanced processing technologies
Food Innovation	Novel technologies	“Review and understand novel processing technologies which could be used to address these raw milk inconsistencies within dairy processing.”	Advanced processing technologies
		“Novel processing technologies”	Advanced processing technologies
		“Buttermilk processing and fractionation including mining for attributes and characteristics”	Product development
Food Processing Technologies	Food Structures	“Bioactivity in food matrix”	Product development
		“Novel application in food matrices to mask flavour”	Product development
		“Enhancements and/or protection of bioavailability through processing (dairy and/or Infant Formula processing) to end products”	Product development

Dairy Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected Impact
Food innovation	Food Formulation	“Processability of dairy ingredients and protection/ optimisation.”	Advanced processing technologies & product development
		“Investigate incorporation of dairy ingredients into nutritional formulations and the processability of those materials”	Advanced processing technologies & product development
		“Healthy fat cheese”	Food & Health and Product development
Food Safety & Quality	Food Safety & Quality	“Shelf life improvements”	Food safety
Food and Health	Nutrition	“Natural v’s industrial fat i.e. trans fat”	Food & Health and Product development
Food and Health	Gut health	“Gut flora & functionality i.e. INFANTMET (similar to ELDERMET)”	Food & Health and Product development
		“Cheese as a vector for bioactives: probiotic of vitaminised/ mineralised cheese”	Food & Health and Product development
		Transit survival	Food & Health and Product development
Food Business & Consumer Science	Consumer research	“Deeper understanding of consumer acceptance/ consumer protection’	Product development

Marine origin foods Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected Impact
Food Innovation	Novel technologies	“Increasing convenience through novel processing, including packaging”	Competitiveness
		“New routes to efficiency (Lean Manufacturing)”	
		“Novel processing and retention of nutritional quality”	Competitiveness
		“Functional foods – Algae and other species as a source of functional ingredients”	Functional products and processes
Food Processing technologies	Food Structures	“Understanding the science behind ingredient interactions to develop a structured approach to product formulation/re-formulation with a view to developing improved healthy sea food products”.	Product development
		“Knowledge about the interaction of ingredients (salt, fat, proteins, hydrocolloids, phosphates, etc.) in various marine food systems to enable a more structured approach to product development”.	Product development
Food Innovation	Food Formulation	“New routes to added value seafood products”	Competitiveness
		“Project on functional peptide research”.	Extracting value from meat processing
Food Safety & Quality	Food Safety & Quality	“Aquaculture standards – verification and influencing market penetration”	Resource sustainability
		“Traceability”	Seafood safety
		“Shelf life extension and quality retention”	Competitiveness
		“Microbial environment in marine foods – HACCP controls”	Seafood safety
		“Listeria in salmon”	Seafood safety

Marine origin foods Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected Impact
		“Emerging pathogens”	Seafood safety
		“Research and assessment of marine toxins and development of autonomous forecasting systems for harmful and toxin producing phytoplankton to prevent toxin containing shellfish entering the marketplace”	Seafood safety
Food Chain Integrity	Food Chain Integrity	“Risk assessment models for marine foods”	Seafood safety
Food Chain Sustainability	Food Chain Sustainability	“Definition of the metrics of sustainability of marine species”	Resource sustainability
		“Indicators of environmental quality as a unique selling point	Resource sustainability
		“Non-food use of marine bioactives”	Functional products and processes
		“Waste utilisation and new products”	Functional products and processes
Food and Health	Nutrition	“Nutritional properties of marine foods”	Functional products and processes
		“Peak mental and physical performance diets from marine foods”	Functional products and processes
		“Bioactivity of marine organism extracts”	Functional products and processes
Food Business & Consumer Science	Consumer research	“Gap analysis of consumer needs versus scientific projects”	Consumer sciences
		“Consumer awareness of sustainable marine resources”	Consumer sciences
		“Consumer attitudes to aquaculture products”	Consumer sciences
		“Defining future buying trends and issues for marine products”	Consumer sciences

Prepared Consumer Foods Research Agenda

Thematic Area	Key Investment Area	Potential areas for FIRM projects to address	Industry targeted research area
Food Processing Technologies	Sensory Science	“Research and assessment of natural colours and flavours to develop a colours and flavours toolbox”.	Consumer foods product re-engineering
Food Innovation	Nanotechnology	“Development of a nanotechnology toolbox”	Processing technologies
	Novel technologies	“Development of a process efficiency toolbox for consumer foods manufacturers. This should draw on world-wide research in for example in-line measurement of nutrients and its use in optimising processes and quality and process efficiency in other sectors”.	Process Efficiency & Competitiveness
		“Research and assessment of packaging technology which achieves technical objectives.... and meets consumer needs...”	Packaging
	Food Formulation	“Research and assessment of new salt reduction techniques across the world to develop a salt reduction toolbox. It should address reformulation, replacers, micro-criteria, shelf life, flavour and scale up capability”	Consumer foods product re-engineering
		“Research and assessment of new fat (especially saturated fat) reduction techniques to develop a fat reduction toolbox. It should address reformulation, replacers, fat fractionation, shelf life, flavour and scale up capability”	Consumer foods product re-engineering
		“Research and assessment of sugar level reduction techniques to develop a sugar reduction toolbox. It should address reformulation, replacers, shelf life and scale up capability.”	Consumer foods product re-engineering
Food Chain Integrity	Food Chain Integrity	“Research on waste reduction with a particular focus on (i) BOD reduction to minimise effluent treatment costs (ii) extracting added value from waste and (iii) water use reduction and water recycling”	Process efficiency and competitiveness
Food Business & consumer science	Consumer research	“Consumer research to identify the perceptions of consumers and barriers to acceptance of reformulated products – with the aim of informing both industry reformulation strategies and public health campaigns”	Consumer foods product re-engineering

Fresh Cut Produce & Cereals Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected impact
Food safety and quality	Novel processing technologies	“Generation of vegetables, cereals and cereal products with reduced fungicide and mycotoxins levels.”	Input to new product development
		“Farm to fork approaches for reducing biological and chemical contaminations of plant foods.”	Food safety
		“Isolation, characterisation and application of novel natural anti fungal agents for the agricultural industry. “ “Optimising of the use of natural preservatives”	Food safety Food safety
		“Devise novel processing technologies so as to achieve the best compromise of safety and the extension of the shelf life of perishable products.”	Input to new product development
	Food chain sustainability	“Greener technologies”	Resource sustainability
	Functional ingredients/ foods and bioactives	“Mining for natural preservatives”	Product development
		“Isolation, characterisation and application of novel anti-microbial/ fungal agents.”	Product development
	Food processing technologies	“Survey on current production and harvesting practices and the development of new protocols.”	Competitiveness
Food and health	Functional ingredients /foods and bioactives	“Bioactive mining from important Irish crops.”	Functional products and processes
		“Mining of traditional Irish plant foods for health promoting compounds.”	Functional products and processes
		“Full chemical and biological activity characterization of mushrooms. “	Functional products and processes
		“Potential new benefits of phytochemicals from mushrooms in human diet.”	Product development
		“Revealing the potential of fungi as a metabolite producer for the pharmaceutical and functional foods industry.”	Functional products and processes

Fresh Cut Produce & Cereals Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected impact	
	Novel processing technologies	“Optimization of bioactive recovery. Up-scale processes for Industry.”	Competitiveness	
	Food structures	“Assessment of structure-activity relationship of common Irish phytochemicals.”	Input to product development	
	Food chemistry and formulation	“Development of new specific in-vitro, in-vivo and in silico bioassays for elucidating bioactive mechanism of action.”	Competitiveness	
	Food processing technologies		“Assessment of factors during production, processing and storage that impact the levels of Vitamin D in fresh cut produce.”	Input to product development
			“Post harvest strategies for increasing the nutritional and technological profile of Irish origin plant foods.”	Input to product development
	Nutrition	“Intervention studies to back up the benefits of mushrooms against obesity, CVD and other chronic diseases.” “Cereal foods for specific dietary needs.”	Food and health Product development	
Food processing technologies	Novel processing technologies	“New processing technologies (HPP, PEF, US, plasma, ozone, replacing chlorine). Use of hurdle technologies to improve quality. “	Competitiveness	
		“Modified Atmosphere Packaging”	Competitiveness	
		“New packaging technologies/systems. Active and intelligent packaging.”	Competitiveness	
		“Development of novel polymers that enhance fresh produce (including mushrooms) through the logistical chain.”	Competitiveness	
	Food chain integrity		“Development of new smart sensing systems for the food industry. On-line monitor sensing.”	Competitiveness
			“Evaluation of new and adapting existing sensor systems for rapid testing in raw materials and in processed material. On-line sensing.”	Competitiveness

Fresh Cut Produce & Cereals Research Agenda

Thematic Area	Key Investment Area	Potential areas for publicly funded research projects to address	Expected impact
		“Development and/or application of modern technologies for rapid quality assessment.”	Competitiveness
		“The importance of an integrated cold chain management system to improve product quality, shelf-life and financial returns.”	Competitiveness
Food Business and consumer science	Consumer research	“Development of an understanding of Irish consumer behaviour toward food.”	Product development
		“Development of an Irish brand image for plant based foods and implication of same”	Product development
		“Strategies for inducing behaviour changes to healthier diets”	Product development
		“The development of models and strategies to promote consumer informed plant based food research”	Product development
		“Irish brand image in packaging. Analysis of risks.”	Product development
Food chain integrity and sustainability	Food processing technologies	“Green sustainable manufacturing. Life Cycle Analysis. Total Quality approach. Definition of quality in terms of the use.”	Competitiveness
		“Investigation on current technologies and mechanisms to exploit by-products (desk work)”	Competitiveness
	Food safety and quality	“Improvement of quality attributes from by-products.”	Competitiveness
	Functional ingredients/ foods and bioactives	“Mining new bioactives/applications from by-products.”	Input to new product development
		“The “pharming” potential of the Irish horticulture industry”	Input to new product development
		“Added value products from a natural by-product of the mushroom industry”	Input to new product development
	Novel processing technologies	“Novel approaches to modify by-products of the cereal industry to generate ingredients for the food or feed industry.”	Process development and Competitiveness

APPENDIX 3

MEMBERSHIP OF
FOOD RESEARCH
EXPERT ADVISORY
(FREA) GROUP

Name	Organisation
Mr. Dan Browne (Chairperson)	Dawn Meats Group
Prof. Paul Ross	Teagasc
Mr. Declan Troy	Teagasc
Prof Brian McKenna	University College Dublin
Prof. Gerald Fitzgerald	University College Cork
Dr Dermot Hurst	Marine Institute
Dr Aileen McGloin	SafeFood
Prof Alan Reilly	Food Safety Authority of Ireland
Ms Sinead McMahon	Consumers' Association of Ireland
Mr Paul Kelly	Food & Drinks Industry Ireland – IBEC
Dr. Keith O'Neill	Enterprise Ireland
Prof Michael Devereux	Institutes of Technology/DIT
Mr Donal Buckley	Bord Iascaigh Mhara
Ms Muireann Kelliher	Glanbia plc
Mr Larry Murrin	Dawn Farm Foods
Mr Pdraig Brennan	Bord Bia
Prof. Charlie Daly	European Technology Platform
Secretariat: Richard Howell Carol Howard Dr. Pamela Byrne	D/Agriculture, Food & the Marine

Other representatives from Industry, Higher Education Institutes and Research Performing Organisations contributed to the work of the group on an ad-hoc basis







Department of
**Agriculture,
Food and the Marine**

An Roinn
**Talmhaíochta,
Bia agus Mara**