Functional Foods: Some Pointers for Success

1 December 2010

Compiled and Edited by:

Ronan Gormley
UCD Institute of Food and Health, University College Dublin, Belfield, Dublin 4, Ireland (e-mail: ronan.gormley@ucd.ie)

and

Finn Holm
Food Group Denmark, Løgten, Østervej 3, DK-8541, Denmark (e-mail: finn.holm@foodgroup.dk)

e-Publication, UCD Institute of Food and Health, Belfield, Dublin 4, Ireland, 1 December 2010

ISBN : 978-1-905254-53-8

DISCLAIMER: The opinions expressed in this publication are those of the authors of the 42 articles and represent their views on the status of each topic at time of writing.

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INTRODUCTION

The **FunctionalFoodNet (FFNet)** project (January 2006-March 2008) was an information source on functional foods for food companies and especially for SMEs. It also networked companies and helped them explore **business opportunities** in functional foods. The FFNet website was an **Information Centre** on functional foods for companies and contained many outputs from functional foods research funded by the EU Commission under its Framework Programmes. Over 190 companies participated in FFNet. The FFNet website (www.functionalfoodnet.eu) will be closed in 2010 and some of its pages are reproduced here, notably the Functional Foods News page which contains 42 commissioned articles by experts on aspects of functional foods. The pages on (i) functional food projects funded by the EU, and (ii) key contact organisations/agencies in functional foods are listed in Appendices 1 and 2 respectively.

Interactive workshops/meetings were the kernel of FFNet and served a dual function: (i) presentations by experts on recent developments in functional foods, and (ii) the companies had an excellent opportunity to interact with each other and to form new business associations/joint ventures on aspects of functional foods.

FunctionalFoodNet was funded under the EU 6th Framework Programme and was coordinated by Finn Holm of Food Group Denmark with Ronan Gormley of UCD Institute of Food and Health, Dublin 4, and formerly of Teagasc Food Research Ashtown, Dublin 15 as assistant coordinator. The coordinator and assistant coordinator together with four other persons formed the Management Committee of the project.

Apples/apple products with reduced allergenicity

By Karin Hoffmann-Sommergruber, and the SAFE consortium, Dept of Pathophysiology, Medical University of Vienna, Austria
e-mail: Karin.Hoffmann-Sommergruber@meduniwien.ac.at

Apples represent a healthy and valuable contribution to the daily diet. However, a considerable percentage of food allergic patients have to avoid this delicious fruit. The multidisciplinary consortium of the SAFE project set out to (a) identify pre-existing apple varieties and their range of allergen load, (b) recommend post-harvest storage conditions that minimize the allergen content, and (c) develop strategies aimed at low allergen varieties to offer new alternatives for the allergic consumer. In parallel to inhalant allergies, the prevalence of food allergy seems to be on the rise. This IgE mediated disease affects about 6-8% of children and 2-3% of adults and represents immune responses to usually harmless dietary proteins. Allergic reactions range from rather mild symptoms (itching and swelling of the oral mucosa) to severe problems such as urticaria, asthma, diarrhoea and even anaphylactic shock.

Diagnosis and therapy

Diagnosis of food allergy comprises case history, *in-vitro* diagnosis and *in-vivo* tests (skin prick tests and food challenges). **At present, the only treatment for food allergy is avoidance. Avoidance can be problematic (hidden food allergens) and potentially lead to an unbalanced diet.** Against the background of the increasing prevalence of allergies in Europe, the European Commission has realized that improved diagnostic procedures and extension of therapeutic possibilities are urgently needed. In Europe, apple allergy appears as two types: firstly, the pollen-fruit syndrome, frequent in areas where birch trees grow, and generally expressed as mild symptoms; secondly, the food allergy against

apples and related fruits such as peach and plum typical of Southern Europe and generally more severe. Both types are related to allergenic proteins present in apple fruits.

Relevant apple allergens

In apples, four allergens have been identified so far: Mal d 1 is a protein up-regulated upon pathogen attack and cross-reactive to the major birch pollen allergen, Bet v 1-- primary sensitisation seems to occur via the birch pollen allergen followed by cross-reactivity of the specific IgE antibodies binding to the apple allergen. The Mal d 1 allergen has been detected in the apple pulp as well as in the peel. Patients sensitive to this allergen mostly live in the northwestern part of Europe. Cross-reactive Bet v 1 homologues are known to be present also in pear, cherry, hazelnut, celery, carrot, etc. Mal d 2 is a homologue of the thaumatin-like protein (TLP), a major protein constituent of the mature apple fruit. Apple thaumatin-like protein belongs to another pathogenesis-related protein family (PR5) and is currently defined as a minor allergen. Mal d 3 is a member of the family of non-specific lipid transfer proteins (nsLTP) also known as being up-regulated upon plant infections. This protein accumulates in the peel of the apple fruits. IgE binding to Mal d 3 is linked with rather severe food allergic symptoms and is recognized by the majority of allergic patients from the south of Europe, whereas patients from the northern and central parts of Europe hardly display any specific IgE antibodies directed against Mal d 3. This allergen is cross reactive to proteins derived from related species such as peach, plum, and apricot. Mal d 4, which belongs to the profilin protein family, is considered to be a pan-allergen with cross-reactivity to birch pollen profilin.

Can we determine levels of allergens in fruits?

Antibody-based *in-vitro* immuno techniques, *in-vivo* food challenges, and skin prick tests can be used to test the allergenicity of offending foods. We used skin prick test (prick to prick tests) and double-blind placebo-

controlled food challenges for assessment and quantification of possible differences in the allergenicity of a number of apple varieties. For patients' groups reactive to Mal d 1, a ranking of varieties regarding their allergenicity was possible. However, the situation will be different for patients with Mal d 3 reactivity (Spanish, Italian patients). **Therefore, when marketing varieties as low allergenic, clear and unambiguous information needs to be delivered together with the fruits and also a reference to the type of allergy!**

Post harvest treatment of apples and processing regimens for reducing allergen content

Apples are harvested commercially just as they begin to ripen and are then stored for several months to maintain availability for as long as economically desirable. **However, post-harvest treatments have an influence on the allergenicity of fruits and vegetables.** Mal d 1 levels and Mal d 3 levels were investigated in apples under different storage conditions for several months. Whereas the Mal d 1 content increased as a result of storage, Mal d 3, content, measured as amount of isolated protein, decreased with storage time; the rate of overall decrease was greater under controlled atmosphere (2.5 % O_2 and 1% CO_2) as compared to non-controlled atmosphere or ambient conditions.

Can we identify allergen genes and formulate breeding recommendations?

Extensive genetic investigations have identified gene loci for all the four known apple allergens Mal d 1, Mal d 2, Mal d 3 and Mal d 4. These genes have been mapped and their loci determined. Some allergens can be related to numerous loci (in the case of Mal d 1) whereas for others only 2-4 loci have been identified. Sixteen out of 18 different Mal d 1 genes were related to two linkage groups following the duplicated nature of the apple genome. Therefore, Mal d 1 represents a gene family with highly homologous isoforms. In contrast, only 2 genes were identified and

mapped on the apple genome for Mal d 2 and Mal d 3, respectively. For Mal d 4, four genes were determined again following the duplication event of the apple genome. This detailed genetic and genomic information is important for the development/identification of genetic markers relevant for reduced allergenicity. **By intensive interaction with plant breeders the use of such markers in breeding programs will contribute to generate low allergenic apple varieties in a conventional way very efficiently.**

Proof of concept: transgenic apple plantlets low in allergen Mal d 1

Mal d 1 expression was inhibited in apple plants by the use of the RNA interference method. Successfully transformed plantlets displayed a normal phenotype but showed downregulation of Mal d 1 expression which translated into significant reduced allergenicity as shown by skin prick tests and IgE *in-vitro* tests. **This is the first example of a hypoallergenic fruit species low in one allergen which corroborates the feasibility of the production of plant foods reduced in allergen content by gene silencing.**

How does allergy impact on people and what could help them cope with it?

Food allergy has an impact on the quality of life of an allergic patient; the dimension of the socio-economics related to this is not fully understood to date. Since avoidance of the offending food is the only method at hand, a reliable diagnosis and careful individual dietary recommendations are necessary for the allergic individual. Hypoallergenic varieties and processing methods aiming at reducing the allergenic risk are options for the allergic patient. In apple, four different allergens were identified and different allergic patients groups identified with mild or severe symptom patterns depending on their immune response to individual allergens. Individual apple cultivars which were low in one allergen were also identified. This offered an alternative for the respective patient group.

Storage conditions reducing the allergen level were also defined and gene mapping of allergen genes offers new ways for breeding strategies. The possibility of down-regulating the expression of an allergen by genetic modification was also shown. Nevertheless, marketing hypoallergenic apple varieties, either as naturally occurring fruit or those obtained by genetic modification requires constant dialogue with the consumer regarding their needs and expectations, i.e. information on the allergenic properties of fruits also needs to be delivered (to the consumer) together with information on the fruits of choice.

More information : http://www.meduniwien.ac.at/safe/

EuroPrevall: the prevalence, cost and basis of food allergy across Europe

By Siân B. Astley, Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA, United Kingdom

e-mail sian.astley@bbsrc.ac.uk

Introduction

Allergy in general is on the increase and with that food allergy. The numbers of foods causing an allergic reaction as well as the frequency of severe reactions (anaphylaxis) are also rising. But, contrary to popular perception, food allergy is not a common condition. In fact, in the UK, around only million adults (1-2% of the adult population) are food-allergic. The rates are higher in children; up to a million children (5-8% of under 16s) have some form of food hypersensitivity and approximately 200,000 are food allergic although, with the exception of peanut allergy, many of these children will out-grow their food allergy by school age. Clinical experience in Europe and the US suggests that food allergies are limited to a relatively small group of foods or food products, namely cow's

milk, egg, soy, peanut, tree nuts, cereals, crustaceans, fish and seeds (for further information see Table 1 of common food allergies).

Food allergy symptoms

Food allergy is an inappropriate immune response to a protein or portion of a protein found in food. The allergic reaction can occur at a point of contact (e.g. the lips or tongue) as well as throughout the body (systemic). Not all reactions to food are an allergy; it can be food intolerance (e.g. lactose intolerance) or symptoms of disease (e.g. coeliac).

Symptoms of food allergy differ greatly between individuals and may differ in the same person, depending on the route and duration of exposure. For example, blistering and swelling of the lips and tongue may happen immediately whilst nausea and vomiting can arise up to 30 minutes after eating. Common symptoms of food allergy include skin irritation (e.g. rashes, hives and eczema) and gastrointestinal symptoms (e.g. nausea, diarrhoea and vomiting). However, sneezing, a runny nose (rhinitis) and shortness of breath (e.g. wheezing and asthma) are also widespread. Ultimately, some individuals may go on to develop anaphylaxis (i.e. constriction of the airways leading to respiratory distress, urticaria and itching, angioedema, vomiting, hypotension, unconsciousness etc.).

Food allergy aetiology

Food allergy develops in two stages: sensitisation and an allergic reaction. People become sensitised when their immune system encounters a protein that for some reason triggers the complex processes leading to 'sensitisation'. The immune system is primed for an allergic reaction but individuals have no symptoms or warning that they are now food allergic. On eating the food again, an allergic reaction starts causing the release of histamine and the other chemicals, which cause the physiological changes associated with inflammation and the symptoms of allergy. Although other

molecules can act as allergens, they rarely involve IgE or induce the same severity of symptoms.

Sensitisation can occur at any age if infection or other factors disturb normal immune behaviour. Food tolerance is poorly developed in infancy and children are particularly susceptible to developing food allergy. Children who are introduced to cow's milk under the age of six months are more likely to develop milk protein allergy. Some babies are sensitised to peanuts, milk and eggs at or around birth. It is possible that they have been exposed to these proteins in the womb or subsequently during breast-feeding. Thus, the mother's diet may be relevant in the development of food allergies. However, babies are equally likely to develop food tolerance via these routes. Thus, simply excluding food groups during pregnancy and during breast-feeding may not be beneficial, which makes it very difficult to provide clear advice for parents.

The allergy developed is specific but cross-reactivity may mean that someone who is allergic to prawns is also allergic to shrimps, crab and lobster; hen's eggs and other eggs; or cow's milk and the milk from goats and sheep. Some cross-reactions are less obvious but stem from the universal nature of proteins; there are only so many ways you can mix up 20 amino acids and create something different. Hence an allergy to house-dust mites may lead to an allergy to shellfish (molluscs and crustaceans); being allergic to latex increases your risk of becoming allergic to some fruits and vegetables; and wheat allergic people may also be allergic to rye and grass pollen. Those who are allergic to pollen, particularly birch or olive (birch in Northern Europe/olive in Southern Europe), may develop symptoms when they eat hazelnuts, apple, cherries, pears and carrots.

One theory suggests that the modern obsession with cleanliness explains why allergies are becoming more important. The reduced incidence of previously common infections and increased use of antibiotics may have

shifted the immune system towards sensitisation. In truth, however, although we know how people become allergic, the why remains elusive.

Diagnosis and treatment of food allergy

Diagnosis of food allergy is a process of elimination. The first step is a detailed patient history to establish a pattern of reactions to food(s) in order to decide if the facts match with a food allergy: was the reaction quick; did allergy medicines help?; is the reaction always associated with the same food?; did anyone else who ate the same food feel unwell?; how much did you eat before you felt sick?; how was the food prepared? Each question is designed to rule out other causes, such as food intolerance and other health problems, before embarking on a dietary history, which involves a degree of detective work. For example, symptoms associated with fruit yoghurt might be due to the fruit or the milk, and it is important to establish which. The diagnosis of food allergy is subsequently confirmed via more specific investigations. Elimination or exclusion diets are used in patients with long term symptoms, as are positive skin prick or biochemical tests.

The only conclusive demonstration of food allergy (gold standard) is the results of a double-blind placebo-controlled food challenge (DBPCFC). The patient receives at least two challenges, without knowing which includes the food allergen and which the placebo. DBPCFC can also be performed using fresh foods, where the test food is masked/ hidden in another (e.g. peanuts in chocolate). Standardised tests with capsules or tablets, or challenges with food, are technically difficult and not without some risk for the patient. Few hospitals are equipped to undertake this procedure and some patients are so allergic to their candidate foods that such an endeavour would be unsafe and unethical.

At present there is no cure for food allergy. The only treatment is avoidance of the problem foods, but even this can be problematic. There

are some tragic instances of accidental consumption with the majority associated with eating out of the home. Avoidance of allergenic foods can be difficult for the allergic consumer and their families and carers, and food allergy can have a detrimental impact on their quality of life. The weekly shop can, therefore, become a time-consuming costly and frustrating business.

European research and web information

Good reliable information about food allergy – symptoms, diagnosis, resources, treatment and research – is difficult to find whether in books or on the internet. The advice and information offered ranges from the ridiculous to the dangerous whether you are a health professional looking to update your awareness, or a parent of a newly diagnosed food allergic child. For this reason, *FoodAllergens.info* <www.foodallergens.info> has been developed and provides information about food allergy: *for consumers* - information most relevant to allergic consumers and their friends and families; *for the food industry* - food processing and industry regulation issues; and *health professionals* - information on diagnosis and management of food allergy. It also offers access to a food allergy database and information portal. The portal is a resource for identifying reliable food allergy information in major European languages, which has been critically assessed by food allergy experts. FoodAllergens.info is also the primary web-based dissemination tool for EuroPrevall (see below) with information, specifically for consumers, food allergic people, health professionals and the food industry.

The European Union has a large portfolio of food allergy research from the fundamental protein science though to diagnosis and treatment. Two of the FP6 instruments are: (a) GA²LEN (Global Allergy and Asthma European Network, http://www.ga2len.com), a network of 25 research institutes and two European societies representing researchers and patients [European Academy of Allergology and Clinical Immunology (EAACI), European Federation of Allergy and Airways Diseases

Associations (EFA)]; and (b) EuroPrevall: The prevalence, cost and basis of food allergy across Europe, http://www.europrevall.org), a multidisciplinary integrated project involving clinical organisations and SMEs as well as research institutes and universities in 17 European member-states, Switzerland, Iceland, and Ghana.

Table 1 – Common food allergies

Cow's milk	Two out of a hundred infants under one year old are allergic to cow's milk, making it the most common food allergy in childhood. However, most children lose this sensitivity as they grow up with nine out of ten resolved by the age of three. Symptoms are frequently vomiting and diarrhoea in children, with 30-50% also having skin rashes of some type. Although it is unusual for adults to be milk allergic, a small number of children have an anaphylactic reaction to milk and remain allergic into adulthood. The major allergens in milk are the caseins and the whey proteins (e.g. beta-lactoglobulin). Because caseins and whey proteins are similar in sheep, goats and cows, people allergic to cow's milk are usually allergic to these other milks as well and dietary calcium must be sourced from non-dairy foods.
Hen's eggs	Allergy to eggs is usually observed in young children rather than adults, and like cow's milk allergy can disappear over time. Occasionally children suffer from a severe form of allergy, which is not outgrown. The main allergens are the egg white proteins - ovomucoid, ovalbumin, and ovotransferrin. The eggs of other poultry, such as ducks, are very similar to those of hens and can cause reactions in egg-allergic individuals. However, cooking such as boiling to completely solidify the egg reduces its allergenicity.
Shellfish and fish	Although shellfish allergies are unusual in children, reactions to fish are found in both children and adults. The incidence of seafood allergy is higher in populations with a high dietary consumption of fish and shellfish. Severe reactions are frequently found with these foods, including anaphylaxis. Cooking does not destroy the allergens in fish or shellfish, and some individuals may be allergic to cooked but not raw fish. The major allergens in fish are flesh proteins (parvalbumins), which are very similar in all kinds of fish; people who are allergic to cod are also allergic to hake, carp, pike, and whiting. Shellfish allergens are usually found in the flesh as part of the muscle proteins whilst in foods such as shrimps, allergens may occur in the muscle and the shells.
Fruits and vegetables	In general, allergic reactions to fruits and vegetables are mild, often being limited to the mouth (oral-allergy syndrome - OAS). OAS is entirely different from the mild initial oral symptoms of more serious food allergies. The allergens in fruits and vegetables are similar to pollen proteins. Four out of ten people who are allergic to tree and weed pollens are also allergic to some fruits, and people who are allergic to birch pollen are much more likely to be allergic to apples. The proteins in fruits and vegetables are not as complicated as in other foods.

	Cooking destroys many proteins and cooked fruit may be safe for fruit-allergic people to eat. However, because latex allergens are like those found in certain tropical fruits (e.g. bananas), people who are latex allergic may also react to these fruits. Other types of fruit allergy are unrelated to pollen or latex allergy, notably kiwi fruit allergy, and peach and Rosaceae fruit allergy, which is often found in southern European populations; these allergies are severe and life threatening. The non-specific lipid-transfer proteins are thermostable, resisting processing and cooking, and even find their way into fermented products such as wine and beer.
Peanuts	One of the most allergenic (allergy-causing) foods and frequently causing very severe reactions, including anaphylaxis. Allergy to peanuts is established in childhood and usually maintained throughout life. This allergy can be so severe that tiny amounts can cause a reaction; traces of nuts found in processed oils or transfer from cooking/serving utensils can be sufficient to trigger a serve allergic reaction. Other legumes include soya, peas and beans. Whilst allergy to soya is perceived to be a problem, it is far less common than peanut allergy. Legume proteins that cause allergy include the seed storage proteins and a protein that is very similar to the one that causes birch pollen allergen. It is found in textured soya protein but not in roasted beans or fermented products such as soy sauce.
True nuts (tree nuts) including almond, Brazil nut, cashew nut, hazelnut, macadamia, pecan, pistachio, and walnut	While not as well studied as peanuts, tree nuts appear to cause severe symptoms and children who become sensitised to tree nuts tend to remain allergic throughout life. Hazelnut and almond allergies are more like those caused by fruit, and are linked to pollen allergies. Cooking destroys some nut allergens, while others survive intact and roasting may actually create new allergens.
Wheat	Suffered by children and adults alike, wheat allergy appears to be associated with exercise-induced anaphylaxis. The more cereal (wheat, rye, barley, oats, maize or rice) we eat the more likely we are to suffer an allergy. Thus, rice allergy is found more frequently in populations eating ethnic rice-based diets. Wheat, barley and rye contain a range of allergens including the prolamins, which are responsible for triggering Coeliac disease, food allergies and atopic dermatitis. Cereals are responsible for two types of allergic disease: one inhaled (Baker's asthma) and the other ingested (food allergy).

The aims of the EuroPrevall project are to deliver improved quality of life for food allergic people. This is being done by integrating information and by developing tools for use by European food allergy scientists, health professionals, food and biotech industries, consumers, and for those who are food allergic and those who are not. More specifically, this project will characterise the patterns and prevalence of food allergies across Europe in infants, children and adults, which are currently not well documented

making it difficult to understand whether food allergy is on the increase or whether it is simply better diagnosis. Major goals of EuroPrevall include developing methods to improve the quality of food allergy diagnosis, reducing the need for food challenge tests, and on determining the impact of food allergies on the quality of life and its economic cost for food allergic people and their families, workplace and employers across Europe.

For further information about EuroPrevall, please contact Dr Clare Mills (Co-ordinator, clare.mills@bbsrc.ac.uk).

Claims: Where are we now? Where do we go??

By Sandra Tuijtelaars and Carina Madsen ILSI Europe, 83, Avenue E. Mounier, Box 6, B-1200 Brussels
e-mails: stuijtelaars@ilsieurope.be and cmadsen@ilsieurope.be

Health concerns and expected benefits from foods and drinks have increased consumers' interest in healthy eating towards seeking beneficial nutrients and ingredients in foods. Nowadays, consumers expect food products that suit their busy lifestyle, as well as being healthy, appealing and tasty. To maintain their competitive edge, food companies, therefore, need to provide consumers with food solutions tailored to these expectations.

Functional foods

Over the past two decades scientific advances have led to a better understanding of the relationship between diet, dietary compounds and human health. The concept of 'functional foods' encompasses foods and beverages that deliver health benefits beyond the 'normal' nutritional value of foods. A 'functional food' can be a natural food, a food to which a component has been added, or a food from which a component has been removed by technological or biotechnological means.

Health and nutrition claims on food products can be one way for the consumer to easily identify a food with certain functionalities and also for the food industry to signal the positive properties of their products. Nutrition claims suggest that a food has particular nutrition properties due to the energy it provides, the nutrients or other substances it contains. Health claims suggest that a relationship exists between a food and health.

Due to absence of a harmonised legislative framework on the efficacy and beneficial properties of a food or drink product, several countries and international organisations have set up their own codes of practice and guidelines to deal with claims on food. This fragmentation leads to barriers, to a high level of consumer protection, and inhibits the free movement of goods within the European market.

EC legislative framework

In July 2003, the European Commission proposed a new legislative framework on nutrition and health claims to achieve a high level of consumer protection, to improve the free movement of goods within the internal European market, to ensure fair market competition in the area of foods, and to promote and protect innovation in the food sector. The members of the European Parliament and the European Council have heavily debated this proposal.

On 16 May 2006, the European Parliament and the European Council reached a political agreement on the proposed amendments to the regulation. The formal adoption by the Council is expected in autumn 2006. The Regulation will be enforced within 20 days of its publication in the Official Journal. When the European regulation is officially adopted, the European Food Safety Authority (EFSA) will publish detailed guidance

to assist food companies in the preparation and presentation of applications and give advice on the setting of nutritional profiles.

One of the important parts of the new EC regulation is that scientific substantiation is the main aspect of allowing the use of nutrition and health claims one a specific product. In this regard, the regulation acknowledges and references the European Commission Concerted Actions FUFOSE (Functional Food Science in Europe) and PASSCLAIM (Process for the Scientific Support for Claims on Foods) as valuable projects to be taken into account when assessing claims. FUFOSE proposed a scheme to link claims for functional foods to solid scientific evidence. PASSCLAIM resulted in a set of consensus criteria that, if met, should give a reasonable assurance that claims made on foods can be considered valid (http://europe.ilsi.org/passclaim).

Consumer understanding

Consumer understanding of health claims is much less coherent, consistent and 'organised' than any scientific assessment of the substantiating evidence to support the claim. Although health claims are of interest and relevance to consumers, the level of consumer understanding of claims is only partial. However, health claims should assist consumers making informed choices as well as help them identify particular foods and food components with health benefits. It is, therefore, included in the European regulation that food companies have to provide evidence that the health claims they use on foods and food components are understandable and not misleading to the average consumer.

The use of nutrition and health claims on foods has raised concern that claims may hypothetically lead to the consumption of an unbalanced diet. The new regulation will, therefore, restrict food companies to only make claims on foods that meet a certain 'profile'. If two or more nutrients do not meet the 'profile' and exceed the limits set for the nutrients in

question, no nutritional claim can be made. For many of the well-established health claims the Commission will prepare a 'positive' list of allowed claims.

ILSI Europe

The European branch of the International Life Sciences Institute (ILSI Europe) has made considerable scientific contributions to the claims area. It coordinated the EU Concerted Actions FUFOSE and PASSCLAIM. The institute coordinates a wealth of scientific experts groups and organises several workshops a year on topical scientific issues. For instance in April 2006, ILSI Europe organised a successful workshop on *Nutritional Characteristics of Foods* in order to explore science-based approaches to the nutritional characterisation of foods including likely impact on the dietary balance and validation of nutrient profiling schemes. In May 2006, another workshop on consumer understanding of health claims was held to stimulate the debate on how nutrition and health claims can exert effects on consumer behaviour and, in particular, to consider methodologies that can be developed to assess how consumers are able to verbalise what the health claim is and what the food or food component does. More information on the activities of ILSI Europe, and also some publications can be found on its website http://europe.ilsi.org or via info@ilsieurope.be.

Getting information to food companies: - meeting the challenge

By Polly Catchpole, Head of Marketing and Sales, IFIS Publishing
e-mail: P.Catchpole@ifis.org

Unsurprisingly, it has been shown that access to, and use of, information by the staff in an organisation contributes significantly to a company's success. We live in times when there is an ever increasing amount of

information available to us, and it's accessible in more ways than ever. This means that it is now necessary to be able to navigate the world of information to discover the most appropriate solutions and how to access the specific information you need without becoming the victim of information overload.

What types of information are most commonly required?

Food and health professionals working within industry, government, academia or operating independently have a variety of information needs. In manufacturing, technical personnel may be interested in up-to-date processing methods, equipment, or ingredients. Marketing executives require information about competitors and their products, or the latest trends in food consumption and purchase. In R&D, staff may want scientific and legislative information on packaging or nutrition, and the effects of processing on a particular food or ingredient. Nutritionists may require access to the compositional analysis of foods, and medical data. Policy makers may need summaries of key issues so that they can devise regulations and advise the public.

So, how should access the information we need?

There is no right or wrong way to access information, but the key is to ensure that the data you obtain is reliable. It must meet your or your company's requirements cost effectively and be accessible using technology that fits company working practices. Some information will be accessible free of charge and will fulfill your requirements fully. Alternatively, it may only be possible to gain access to certain information by subscription or membership.

The World Wide Web and search engines

Search engines can be a very good way to find free information – most people have used Google at some time but there are a multitude of other search engines (see http://library.albany.edu/internet/engines.html for a

good selection). Some specialise, for example CompletePlanet http://aip.completeplanet.com is designed to retrieve the less accessible information available on the web and lists its content by subject. When using information retrieved by search engines, be aware of what kind of site you are visiting. Is it an academic site, has it been sponsored by an organisation, is it associated to a reputable trade association, learned society or professional body? Some useful types of websites are:

- Trade Associations, Learned Societies and Professional bodies – e.g. the Biscuit, Cake, Chocolate and Confectionery Association (www.bccca.org.uk)
- Government websites - e.g. Food and Agriculture Organisation (www.fao.org)
- Food safety agencies – e.g. French Food Safety Agency (www.afssa.fr)
- Food company suppliers – e.g. Food Processing Technology (www.foodprocessing-technology.com)
- Market research providers – e.g. Datamonitor (www.datamonitor.com)
- Online portals and communities - e.g. Just Food (www.just-food.com)
- Academic and mainstream publisher sites e.g. Woodhead Publishing (www.woodheadpublishing.com)

With the introduction of RSS technology (it stands for Really Simple Syndication *and* Rich Site Summary) it is now possible to receive notification of new information posted on your favourite websites via an RSS newsfeed which can save you time and avoids overloading your email. Look for an 'RSS' button on the site.

Databases

Databases are available to cover every food-related topic from the new products on our supermarket shelves to the latest research in organic

chemistry. Increasingly these are offered electronically, although, some do still exist on CD-ROM and sometimes records are still available in print. They fall into two main categories:

1) **Factual databases-**which contain facts and figures such as food composition data, conversion tables and boiling and freezing points of various substances. Visit the Food and Agriculture Organisation site (www.fao.org/infoods/directory_en.stm) and the United States Department of Agriculture site (www.nal.usda.gov/fnic/foodcomp/) for good examples. See also Ingridnet, www.ingridnet.com - a useful tool for locating ingredient suppliers.

2) **Bibliographic databases-**These collate information from a variety of different sources and their records provide summary information of the original material, e.g. articles, patents and reviews – making it easy to rapidly search a large amount of data for a specific topic. As is the case with factual databases, some bibliographic databases are free and some are accessed via subscription and can be IP linked within an organisation. Here are some examples:

- PubMed/Medline **FREE** – biomedical and life sciences journal literature (www.pubmedcentral.nih.gov/)
- FSTA – Food Science and Technology Abstracts® - specialist food science, food technology and food-related human nutrition records (www.foodsciencecentral.com/fsc/fsta)
- Foodline Legal – current legislation information www.leatherheadfood.com/lfi/submenu.asp?subsection=34&section=7
- CAB Abstracts – applied life sciences including agriculture and nutrition

In addition to being able to purchase databases, there are organisations that provide collections of databases. These vendors (also called aggregators, or host platforms) act like retail outlets for the producers of

individual databases and provide one point of access to a wide range of databases on a single search interface. Some examples are:

- **Ovid Technologies** (www.ovid.com)
- **ISI** (www.isiwebofknowledge.com)
- **Dialog** (www.dialog.com)

Bibliographic databases often provide users with the option to be regularly updated on specific topics via email alerts – these could be daily newsfeeds or weekly updates on what has or will soon be published in the field of food science and can be accessed both from a desk or the more mobile generation of palm held devices.

References works and books

Key reference texts and books are staple tools for day-to-day reference and the introduction of electronic formats of major reference works as databases, simple files or e-books have made them more widely accessible to end-users. For example, Official Methods of Analysis of AOAC International (the chemical and microbiological analytical methods validated by the AOAC Official Methods Programme) is available in print and online.

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The Alimentary Pharmabiotic Centre – where food meets medicine

By Catherine Buckley, Alimentary Pharmabiotic Centre, BioSciences Building, University College Cork, Cork, Ireland
e-mail: c.buckley@ucc.ie

The Alimentary Pharmabiotic Centre (APC) is a Science Foundation Ireland-funded research centre established in 2003 and headquartered at University College Cork (UCC). The APC is a research partnership with multidisciplinary scientists at UCC, Teagasc, Moorepark (the Irish Government Agriculture and Food Development Authority), and its foundation industry partners campus company Alimentary Health Ltd , in association with affiliates the Procter & Gamble Company. The APC also has a research agreement with GlaxoSmith Kline (GSK)

Goals of the APC

These include investigating the means by which intestinal bacteria influence health and disease; developing new therapies for lifelong debilitating gastrointestinal diseases such as gastroenteritis, ulcerative colitis and Crohn's disease; exploring commercial opportunities in both the functional food and pharmaceutical sectors; and positioning Ireland at the forefront of this exciting new area.

According to Professor Fergus Shanahan, Director, *"At the APC we have no limits to the depth and breadth of questions we can ask and answer. We take a truly transdisciplinary approach with a team that includes experts in microbiology, immunology, gastroenterology and molecular biology. Our vision is to make microbes work for mankind through a "bugs to drugs" programme of discovery. We will explore the molecular secrets of how bacteria within the human gut (or "flora") interact with their host; then we will mine the flora and design novel therapeutics for infectious and inflammatory diseases."*

Research activities of the APC

These are encompassed in five core research areas: (i) bacteriocins as tools for influencing gastrointestinal flora; (ii) host response, (iii) pathogen and probiotic interactions; (iv) bacterial genomics and bio informatics; (v) bacterial metabolism and physiology. A key consideration is that APC's research will strengthen claims for the efficacy of functional foods and hence will have an important influence on the development of these foods by Irish companies. In this context, the work of the APC is of tangible importance to several industries including human health maintenance, agriculture and animal husbandry, and is pitched at the interface of the food and pharmaceutical sectors.

The mission of the APC is to link Irish science with industry and society through excellence in research, education and outreach in gastrointestinal health. The APC has established strong links with the Irish community at all levels, actively promoting communication with government, Irish and international industry, and the public, especially schools and young people, on issues such as gastrointestinal disorders, probiotics and functional foods. The APC is committed to keeping the public abreast of new therapeutic developments, ongoing clinical trials, and exciting new research findings.

Dissemination/technology transfer

The APC organises a biannual Food Forum which brings together senior decision makers in the Irish food industry, government policy makers and leading international experts to discuss the opportunities presented to the Irish food industry by the increasing consumer demands for foods that offer health benefits. Lively debate takes account of consumer trends and international developments underpinned by sound scientific knowledge.

"Gut Reaction", APC's industry newsletter includes research news, industry news, staff profiles, details of upcoming events and is distributed twice

annually to scientists and policy makers in the Irish and international food and pharmaceutical industries, government agencies, relevant medical practitioners and the media.

The APC organises public fora on a regular basis to keep the public abreast of issues such as gastrointestinal disorders, probiotics and functional foods, as well as patient open days to discuss new therapeutic agents, ongoing clinical trials and exciting new research findings.

MicrobeMagic@School, the APC's school's programme, encompasses school visits, a website designed especially for children (http://microbemagic.ucc.ie) from which APC's educational computer game **GutReaction** can be downloaded as well as **GutBuster**, a new mobile phone game, and the Microbe Magic schools newsletter.

The outward looking nature of the APC is reflected in its multinational flavour with research staff from over 20 countries and its involvement in new collaborative research initiatives with international research teams including The University of Life Sciences, Norway, and the Wageningen Centre for Food Science (WCSF) in the Netherlands which held its annual research retreat in Cork last summer. The APC is a wonderful Irish opportunity for bright young scientific minds. The Centre is a hub of research excellence, providing outstanding facilities with an invigorating and challenging research environment.

Research collaboration with GlaxoSmith Kline

A research partnership between GlaxoSmith Kline (GSK) and the APC is ongoing. Researchers from GSK's Neurology and GI Centre of Excellence for Drug Discovery (CEDD) will work closely with the APC to identify new drug targets for the treatment of inflammatory bowel disease and irritable bowel syndrome (IBS) by exploiting the drug discovery capabilities of GSK's and the APC's unique understanding of these diseases. The project

is jointly supported by IDA (Industrial Development Authority) Ireland and Science Foundation Ireland and will involve investment of up to €13.7m.

Three major areas of research are covered by the new GSK-APC venture:

*Exploratory scientific research

*Bench-to-bedside medical exploratory studies with known molecular entities developed in-house by GSK

*Drug discovery using GSK technology and APC enabling tools and technology

Keep in touch

Keep in touch with the APC through http://apc.ucc.ie and http://microbemagic.ucc.ie (for children) and its newsletters GutReaction (for industry), MicrobeMagic (schools) and InsideOut (patients and professionals in the medical community).

Irish Phytochemical Food Network:- tracing phytochemicals from farm to fork

By Juan Valverde, Teagasc, Ashtown Food Research Centre, Ashtown, Dublin 15, Ireland
e-mail:juan.valverde@teagasc.ie
website: http://www.ipfn.ie/

In March 2008, the Irish Department of Agriculture, Fisheries and Food agreed to fund the creation of a phytochemical research network of Irish experts (FIRM Ref. Num. 06/NITARFC6). The main objective of the network is to collate scientific expertise on phytochemicals (plant bioactive compounds) found in Irish grown fruits and vegetables. The creation of this network resulted in a collation of existing knowledge and the generation of new information, thus ensuring that maximum benefit is

derived from the collective expertise. In addition, the Network model provides the opportunity to get the most out of available resources particularly through a reduction in unnecessary duplication, identification of knowledge gaps, less fragmentation of activities, and greater cooperation and collaboration**.** Many factors have been shown to affect phytochemical levels in foods. To date the mechanism of action, stability during food processing, effect of agricultural factors, and stability in post harvest storage on these compounds is not well understood. Therefore, there is a need to assemble existing knowledge and provide holistic information on the fate of these compounds up to their site of action.

Phytochemicals occur in virtually all plants, and are common constituents of fruits and vegetables that are part of the human diet. Numerous studies suggest that phytochemicals can be responsible for considerable health benefits to humans such as reduction of the risk of developing many forms of cancer (lung, prostate, pancreas, bladder and breast) and cardiovascular diseases, and/or other benefits such as anti-inflammatory properties. The new research will examine the influence of agronomic factors (*e.g*. soil type, seasonal variation…), processing and storage on levels of phytochemicals in selected vegetables. In addition, the initiative will focus on developing an understanding of consumer attitudes to phytochemicals.

According to data from the **Food and Agriculture Organization** of the United Nations (FAO, www.fao.org), members of the (a) *Brassicaceae* family e.g., cabbage, cauliflower, broccoli (b) *Apicaceae* e.g., carrots and parsnips and (c) *Allium* family are, after potato, the main crops produced in Ireland (Figure 1). Brassicas with a production around 100,000 tons/year are at the top of the production ranking in Ireland, followed by carrots with a production of over 20,000 tons/year and finally onions with an annual production of around 10,000 tons/year (Figure 1).

Therefore, the Irish phytochemical food Network is initially focused on three groups of phytochemicals in three main Irish grown vegetables. These phytochemicals are:

Polyacetylenes

Polyacetylenes are examples of bioactive secondary metabolites that were previously considered undesirable in plant foods due to their toxicant properties (*1*). However, a low daily intake of these "toxins" may be an important factor in the search for an explanation of the beneficial effects of fruit and vegetables on human health. For example, polyacetylenes isolated from carrots have been found to be highly cytotoxic against numerous cancer cell lines (*2*). Over

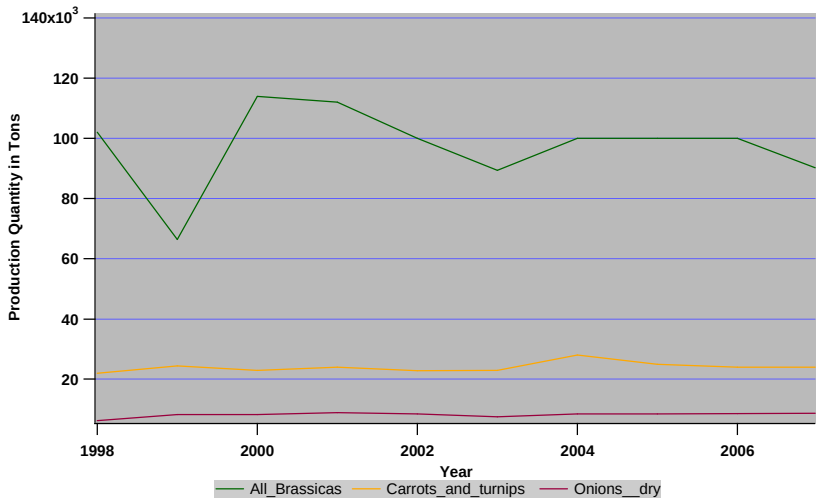

Figure 1: Quantity (tons) of brassicas, carrots, turnips and onions produced in Ireland since 1998 to 2009 (Data source: FAOSTAT, online database of the statistics division of the Food and Agriculture Organization of the United Nations: http://faostat.fao.org).

1400 different polyacetylenes and related compounds have been isolated from higher plants. Falcarinol, a polyacetylene with anti-cancer properties, is commonly found in the *Apicaceae*, *Araliaceae* and *Asteraceae* plant families (*2*):

Polyphenols

Polyphenols are a class of compounds characterized by the presence of one or more phenol unit, or building block, per molecule. Polyphenols are a widely investigated and diverse range of compounds. While numerous *in-vitro* studies have demonstrated that polyphenols have potential health promoting benefits, their biological mechanism of action and efficacy in human dietary intervention studies is as yet unknown. However, their biological mode of action is most likely related to their ability to scavenge harmful free radicals (*3*). Reactive oxygen species (ROS) generated during oxidative stress can react readily with bio-molecules (DNA, RNA, proteins…) damaging their structure and hence modifying their biological role. This leads to DNA lesion, function loss in enzymes, increased cell permeability, disturbed signaling over the cell, and to cell death (apoptosis) among others; ROS are also involved in inflammation. It is assumed that antioxidants react with radicals to prevent cellular compounds becoming oxidized and, therefore, protecting the cell from the ROS. For example, there is growing evidence that quercetin (a flavonol) might inhibit the growth of tumour cells containing type II estrogen binging sites, including breast, colon, ovarian, leukaemia, gastrointestinal and meningioma cancer cells (*4*). Quercetin and related compounds might also protect against cardiovascular diseases and stroke by participating in the reduction of platelet aggregation and vasoconstriction (*3*).

Major sources of polyphenols include berries, tea, beer, grapes/wine, olive oil, chocolate/cocoa, coffee, walnuts, peanuts, pomegranates, and other fruits and vegetables (*5, 6*). High levels of polyphenols can generally be found in the skins. Plants from the *Allium* family, such as onions, garlic or leek are particularly rich in polyphenols (both quantity and variety). Plants from the cruciferous family are rich sources of phytochemicals called glucosinolates.

Glucosinolates

Structurally glucosinolates (β-thioglucoside-*N*-hydroxysulfates) are characterised by the presence of nitrogen and sulphur groups, and are derived from glucose and an amino acid. Glucosinolates act as secondary metabolites in cruciferous vegetables (*Brassicaceae*, *Capparidaceae* and *Caricaceae)* and also in the genus of *Drypetes* in the *Euphorbiaceae* family (*7*). Although their role in plants is unclear, their potent odour and taste suggests a role in herbivore and microbial defence. Glucosinolates are not bioactive until they have been enzymatically hydrolysed to the associated isothiocyanate by the endogenous myrosinase enzyme that is released by disruption of plant cells though harvesting, processing, or mastication. More than 120 types of glucosinolates, with varying side chains, have been isolated, but not all of these are present in edible plants (*8*). Polyacetylenes, polyphenols and glucosinoltes represent only a fraction of the huge range of phytochemicals present in fruit and vegetables varieties. The Network will eventually focus on other interesting phytochemicals such as carotenoids, terpenoids, phytosterols and alkaloids from many different sources such as fruits, green leafy vegetables and potatoes.

Expected outcomes

The expected impact of the Network is to gain better understanding of the role and biological modes of action of phytochemicals at molecular, cellular and whole-organism level. A greater understanding of the roles of phytochemicals in promoting health will lead to improved formulation of foods, and to recommendations for consumers concerning the specific contribution made by individual bioactives in foods. The new food formulations, accompanied with nutrition and health claims, will increase competition and trade opportunities in Europe. European/Irish recommendations to promote health will be developed, taking into account the diverse eating patterns in Ireland. The results will provide sound

scientific data to support the common European policy on health and nutrition claims.

More information

Visit http://www.ipfn.ie/ or e-mail juan.valverde@teagasc.ie

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Functional food projects in Nordic countries

This project compendium was assembled by Joop Luten, Fiskeriforskning (Norwegian Institute of Fisheries and Aquaculture Research), Muninbakken 9-13,Postboks 6122, N-9291 Tromsø, Norway
e-mail: joop.luten@fiskeriforskning.no

Nordic Innovation Centre (NICe) has granted 6 projects within its focus area of Functional Foods. Several activities and results can be expected yearly throughout the duration of the functional food focus area from 2006 to 2009. The project portfolio presented below has been recommended by Nordic evaluation groups consisting of different stakeholders. These projects were considered the best project combination in order to reach the overall goal of this initiative to support the Nordic food industry in becoming an active, competitive and successful player in the fast growing functional food market.

Rye and wholegrain – The Nordic opportunity (GRAINITY)

Wholegrain, rye and oat products are traditionally important in the Nordic diet and as Nordic export items. Interest in such products is increasing globally. With the current trend of healthy eating, and recognised health benefits of fibre, there is a need and opportunity to build on the rye and oat expertise by joint efforts of academia and industry. The evidence of health effects of whole grains has already led to acceptance of health claims for marketing of whole grain foods in the US, UK and most recently in Sweden. There is a clear need of harmonizing the claims, and the definitions and criteria behind them. The overall objective of GRAINITY is to strengthen the cereal based food industry in the Nordic countries in the development of functional whole grain food products. The specific aims are:

- to increase the competitiveness of the rye, oat and whole grain based Nordic food industries by building a platform to fully exploit the on-going scientific research

- to provide facts and shared Nordic views to harmonise and substantiate nutritional and health claims of rye, oat and other whole grain foods.
- to identify joint R&D needs for bringing new types of rye, oat and other whole grain products to the market
- to extend the Nordic collaboration in functional cereal foods to the Baltic countries

Expected outcomes are:

1. That the Nordic cereal industry will be a leading actor in the increasing healthy cereal foods market.
2. Increased quality of innovation within the cereal based industry
3. New networks between science and industry

For more information contact project leader: Kaisa Poutanen, VTT Technical Research Centre of Finland. For more information see http://www.vtt.fi/proj/grainity

Human testing of foods: – requirements and level of proof?

The lack of consensus on the level of scientific support and documentation required for health claims is a bottleneck in the process of developing and marketing functional foods. This project aims to establish a Nordic/Baltic consensus on requirements, techniques and methodologies for human studies on functional foods and ingredients. A cluster within the area of human testing of foods will be working with the objective to define what level of evidence is necessary for scientifically assessed and documented health claims in the Northern countries. PASSCLAIM will be used as background material. Four thematic working groups are established covering:

- Intervention studies
- Animal studies
- Biomarkers
- Epidemiology in relation to health claims on food

The project will also host a dialogue between the actors in the Nordic countries in relation to influencing the national political decisions regarding health claims on food and foodstuffs. The project will work on enabling discussions of possible health claims aiming at a shared understanding to be used politically in EU negotiations on health claims due during mid 2007. The final outcome of the project will be:

- A report on health claims that can create the basis for the national submission of health claims to the European Union (autumn 2007)
- Recommendation for level of proof and good and best practice for heath benefit documentation to underpin the health claims (summer 2008).

Project leader: Maria Olofsdotter, Øresund Food Network;
see http://www.oresundfood.org/

Consumer acceptance and trust: recommendation for using health related claims in marketing (ACCLAIM)

Relatively little knowledge is available on consumer reaction to health-related claims for functional foods, even though this is a crucial factor for the industry and regulators to know. The main objective of the project is to develop a shared Nordic view among stakeholders on how health claims should be used in marketing functional products. The aim is to map the existing practices, study consumer understanding of claims and based on consumer results build a consensus among Nordic stakeholders in a set of workshops. The project will examine the different practices in regulatory systems and interpretations of regulations on functional foods within Nordic and Baltic countries. Additionally, a study of consumer responses to health claims in functional foods based on a survey will be made. The survey will detect shared opinions among the Nordic countries as well as the discrepancies between countries. Finally, recommendations will be developed for interpreting and governing regulations on functional foods with a special attention on marketing practices of foods with health claims in the Nordic market.

Project leader: Liisa Lähteenmäki, VTT Technical Research Centre of Finland

see http://virtual.vtt.fi/virtual/acclaim/index.htm

Nordic Network for Marine Functional Food (MARIFUNC)

Several seafood components have gained interest as potentially bioactive and health promoting ingredients. Still, substantial evidence for health beneficial claims is limited. The overall goal of the project is to strengthen the marine based food industry in the Nordic countries in the development of innovative marine functional foods or marine food ingredients. The project focuses on the use of fish, nutrients and other bioactive substances isolated from fish, as ingredients infunctional foods. MARIFUNC is a pro-active platform to share the strategic intent and common goals for marine functional foods through discussion and communication between industrial stakeholders and scientists from various disciplines in an integrated approach including health claims, consumer acceptance and innovative consumer driven marine functional food development. The platform will act as an initiator and catalyst for strategic activities.

Deliverables: The project will publish reports on the following topics:

- Health effects and claims for marine food or ingredients in marine foods
- Consumer attitudes to marine functional foods
- Possibilities for developing innovative new marine functional food products
- Needs, ideas and strategy for marine functional foods from SME and industrial partners

The project will also make available new scientific information on:

- Seafood lipids
- Seafood proteins, peptides and water soluble components
- Probiotics

Project leader: Joop Luten, Fiskeriforskning (Norwegian Institute of Fisheries and Aquaculture Research). See website www.marifunc.org

Substantiation of weight regulation and satiety related health claims on foods

There has been a dramatic increase in overweight and obesity in all Western countries. Overweight and obesity are thought to be important risk factors for many chronic diseases. Identification and communication of food properties that may be helpful in prevention and management of overweight is important. New EU-legislation will most probably permit the use of weight regulation and satiety-related health claims on food, thus making claims related to prevention of obesity one of the most important health claims made for functional food products. The objective is to create a common Nordic platform with respect to substantiation of health claims in the field of weight regulation and satiety. The ultimate objective is to have a common practice in Nordic countries for assessing evidence for weight regulation and satiety related claims, which would give a competitive edge to the Nordic countries. The project will collect available data concerning weight regulation and satiety and evaluate the methodology used with respect to suitability in substantiation. A final report will conclude and give recommendation regarding use of weight regulation and satiety related health claims on food in the Nordic countries.

Project leader: Marjatta Salmenkallio-Marttila, VTT Technical Research Centre of Finland.

SMEs commercializing healthy nutrition

Many of the most successful products and concepts in healthy nutrition worldwide have been brought to market by fairly small companies. In general, little is known about Nordic SMEs active in functional foods and health ingredients. Commercialising functional foods is a challenge. The Nordic countries have a strong competence in applying science and technology, but commercial aspects of the innovation process are often neglected and promising inventions fail to succeed. The hypothesis for this project is that Nordic companies lack the capability to fully manage,

exploit and develop the innovations to reach their full commercial value. This project will focus on SMEs and their activities. Through the project better and deeper understanding will be gained regarding the issues of innovation acceleration, entrepreneurship, strategies to enter the market, and best practices. The overall objective of this project is to increase the knowledge about Nordic SMEs active in the business of functional foods, which consequently will:

a) help policymakers to set up strategies to better support SMEs,

b) help SMEs gain more insight into their business and how to strengthen commercialisation processes and marketing capabilities. Aims are:

- To provide an overview and generate information and insight about the Nordic SMEs active in functional foods/ health-enhancing foods/health ingredients
- To provide comprehensive analysis of their commercialisation processes and target issues
- Communication and networking aimed at sharing experience, resources, information and knowledge for the benefit of the SMEs.
- International benchmarking – best practices highlighted, strengths, weaknesses identified.
-

Project leader: Patricia Wiklund, Invenire, Finland.

see also www.invenire.fi/nice

Functional Foods in Spain: - an industry perspective

By Marisa Vidal-Guevara, Research Scientist, Hero Spain, S.A.
e-mail: marisa.vidal@hero.es

The functional foods sector in Spain is one of the most forceful, with sales growing by 15-16 per cent every year. In 2006, functional food turned over 3500 million Euro. This peak was due to the ageing of people, the

increment of purchasing power, and the change of life styles associated with working habits; this means that home-made food loses ground to fast food. Decrease in cholesterol, weight loss and improved gastrointestinal health are three of the major benefits offered by functional foods to the Spanish consumer.

Functional food surge

The surprising peak for functional foods in Spain emerged in the 1990s. The reasons were diverse: 1) the public are more concerned about health and acquire foods with high added value; 2) organizations in charge of legislating this matter realise the beneficial effects of functional foods on public health; 3) the government is paying attention to this sector because it anticipates the economic potential of these products, as one of the prevention strategies in improving public health. Other factors also contributed, like technological advances (biotechnology), and the scientific research which supports the health benefits of these foods.

Experts are in agreement that these foods are not a fashion and they have arrived to stay in the market place for the long term. In this sense, the normative for their labelling is now highly developed; this is a complex process because of the required scientific studies and economic interests of food industries. Spain is in the vanguard of the functional foods industry and, therefore, can be used as a reference point for developments in functional foods. Functional foods commanded a 26% share in the Spanish food market in 2007.

Spanish diet

The traditional Spanish diet corresponded to the food standard defined as the Mediterranean diet. Most representative foods in the Spanish diet have been consumed for many years, e.g. vegetables, legumes, fruits, a rich variety of fish, olive oil and red wine. The consumption of meat and dairy products was moderate. However, in the last 30 years important changes

have been observed in the food behaviour of the population, according to data of the Spanish Ministry of Agriculture, Fish and Food (2001). These changes are mainly a decrease in consumption of complex carbohydrates, vegetables, fruits, red wine and sugar, and an increase in fish, dairy products and meat consumption.

Speaking about nutritional paradoxes, the Spanish paradox is observed like Greek and French. Overweight is associated with a higher mortality and it is considered that obesity is directly responsible of 7.8% of deaths in the European Union. Of these, 70% are a consequence of cardiovascular diseases and 20% of cancer. In Spain, the obesity indices have significantly increased during the last decade. However, the mortality indices are lower in comparison with other European populations with similar obesity levels. The dietary antioxidant hypothesis (Spanish or Mediterranean) may be a possible explanation of this paradox.

Concerning the beliefs of Spanish consumers, they have a strong belief that the Spanish Diet is still a Mediterranean Diet, with the associated benefits, and have not been consuming functional foods, claiming that their diet is healthy enough for a healthy life style. However, this argument does not stand up when viewed against a wide percentage of the population with high levels of cholesterol, triglycerides or blood sugar, hypertension and obesity, which lead to diabetes and/or cardiovascular diseases. Special dietary recommendations need to be considered at this moment, and functional foods are now finding an important space in the market. Consumer acceptance of such foods is the key factor in the development of the functional food industry and consumers must be convinced of the health benefits which functional foods offer. The food industry must not label products without previous validation of the beneficial effect/s, and regulatory organisations must allow only those health claims that are duly validated. The Spanish food industry is making a greater use, day by day, of academic resources to evaluate and validate

the beneficial effects of their products, looking for efficient biomarkers which demonstrate the effect on organic functions, including their role on health keeping and disease prevention, and also cause-and-effect relationship studies to evaluate safety and dose level. The second effort is clear and transparent communication to consumers.

Opportunities for the food industry

From an industry perspective, strong efforts are being taken to launch new products, designed with special ingredients which could reduce the risk of most of the important and chronic diseases observed in the Spanish population; this also includes validating their beneficial effects. During 2008, 38 new launches of functional foods have been carried out---12 products with functional-digestive claims, 8 products with functional-immune system claims, and several of them fortified with vitamins and minerals, and low in sugar and/or calories. Of special relevance are infant products, with 6 new launches in the last 5 months.

In this regard, the most important factor is close collaboration between food companies and research centres, but also with public organisations in order to offer to the consumer a choice of well designed functional food products with proven efficacy.

Food for thought—functional foods open up new opportunities for Ireland's marine food sector

By John Joyce and Dermot Hurst, Marine Institute, Oranmore, Galway, Ireland
e-mail: John.Joyce@marine.ie

Europe's population is getting older, richer and more health conscious. According to UN Statistics, 16.6% of the EU's 500 million citizens are over 65 years old and one in 25 is over eighty. As we get older our minds turn

not only to getting old "gracefully" but, more importantly, to getting old in good health. We turn to countries such as Japan—where average life expectancy is just over eighty—and wonder how they do it. We find that the answer lies in the sea—in the rich tradition of the Japanese fish and seaweed diet. This leads to the logical conclusion that, by mobilising Ireland's research community to build on its marine and food research capabilities, Ireland can develop entirely new marine based food products that help to maintain a healthy population, and offer new and exciting opportunities to its traditional seafood and processing industries.

Sea Change

In 2005, Ireland's Marine Institute undertook a series of foresight exercises, as well a wide-ranging consultation process with stakeholders, across the complete spectrum of the marine sector as a preparation of *Sea Change*—A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013. One scenario forecast by this process was that, by the year 2020, Ireland could possess both the science-based capability and the capacity to develop new functional food opportunities, tapping a market that was valued at $75.3 billion worldwide in 2005 and adding value to available marine materials, organisms and extracted compounds from around the Irish coast.

Through this applied research, traditional Irish marine food processing firms could become proficient in new processes designed to extract, separate, purify and package marine origin compounds. Marine products could then make an important contribution to the development of a high added-value functional foods industry in Ireland, through strong inter-agency partnerships and synergies with other RTDI performers in the food sector.

To make this scenario a reality *Sea Change* set the following tangible objectives for the year 2013, including the creation of "a strong,

interdisciplinary research capability in the identification and utilisation of marine biodiversity as a source of materials for use in functional foods."

It also proposed a number of practical actions to achieve its objectives including; the active participation by state and third-level research institutions and industry in national and internationally funded programmes and international collaboration, as well as the establishment of three new research teams under *Sea Change*, with additional funding to be leveraged over the period from Science Foundation Ireland (SFI), the Higher Education Authority (HEA), industry and international sources.

Meanwhile, Ireland's national Strategy for Science, Technology and Innovation (SSTI) also recognises that "as lifestyle related illnesses such as heart disease, obesity, cancer and diabetes become more prevalent and consumers seek healthy alternatives," there is "scope for improved performance in the Pharma, Health and Food Sectors." Given the fact that health concerns are now a major influencing factor on consumers, SSTI suggests that Ireland's strategy should be to increase R&D in Functional Foods, which it forecasts as being one of the key drivers in the sectors and which, it believes, that Ireland has already built a strong capability through publicly-funded programmes.

Marine bioactives

The potential for Ireland to become a major supplier of raw materials to the highly lucrative functional food sector has also been recognised by the 2006 Cawley Report on the Irish fishing industry—"Steering a New Course"—which recommends a programme of investment to "create a strong interdisciplinary research capability in the identification and utilisation of fish and marine biodiversity as a source of materials for use by the functional food sector." It also highlights the three specific areas of research already proposed by participants attending the Marine Functional

foods workshop; pelagic species (such as mackerel and herring), seaweed and marine origin waste materials.

All of this opens up new and exciting opportunities for the Irish seafood processing sector in the production marine "functional foods"—which are not only tasty and nutritious to eat, but can also be manufactured to have positive benefits in protecting the consumer from a wide range of ailments including obesity, diabetes, lowered immunity and even cancers.

As a key step towards the objectives proposed by *Sea Change*, the Marine Institute hosted Ireland's first Marine Functional Foods Workshop on 26th January, 2007 at its headquarters in Oranmore, Galway, Ireland. The workshop was addressed by international experts in marine origin functional foods research and was charged with defining and prioritising research themes relating to functional foods and ingredients that could form the basis of a series of research calls to be funded under the next National Development Plan (2007-2013).

Research Initiative

Accordingly, a Marine Functional Foods Research Initiative (MFRI), was established jointly by the Marine Institute and the Irish Department of Agriculture, Fisheries and Food (DAFF), and supported by national research funds. It is designed to support a consortium of research institutions—decided by open competition—to develop collaborative research in the areas of food, health, marine and ecological sciences aimed at improved and ecologically sustainable use of Ireland's marine resource. The consortium is being funded by MFRI to engage in research relating to marine food.

The research programme is exploring and delivering new knowledge relating to the identification, extraction and validation of bioactive marine compounds and the verification of their physiological effects. It will also

develop the required expertise necessary to evaluate the potential of such compounds for use in functional foods and as food ingredients.

As an illustration of the commitment to develop new capability in this area, the scientific programme is designed to last a minimum of seven years and will be expected to supplement initial funds by competition for international research grants.

In return for this commitment, the research consortium is required to deliver an initial report, within 18 months, on the status of international research in marine functional foods that identifies knowledge gaps that can be filled by new Irish research to be performed by the consortium.

Road map

With this report as a road map, the consortium is moving forward on an agreed programme of fundamental research to develop a lasting competency on marine functional foods and ingredients—including how to develop functional foods and ingredients from sustainably harvested marine species; research training of additional post-graduate students to develop additional capacity; dissemination of research outputs through workshops, conferences and publications.

While it is accepted by the MFRI that not all research will lead to commercial products, the consortia will be encouraged to seek the involvement of industry in support of the research programme and to develop new opportunities for Ireland's marine and food sectors.

The Marine Institute was created under the Irish Marine Institute Act in 1991 and has grown into an internationally respected science body with over 200 staff, two purpose-built vessels – RV Celtic Explorer and RV Celtic Voyager, a research facility near Newport, Co. Mayo and now a brand new headquarters and laboratory on the shores of Galway Bay. To learn more about the Marine Institute see www.marine.ie

Searching the world for plant bioactives

By Alvin Ibarra, Naturex, Site d'Agroparc - BP 1218 - 84911 Avignon cedex 9, France
e-mail : A.IBARRA@naturex.us

Naturex manufactures and sells plant extracts for the food, flavour and nutraceutical industries. These extracts are classified according to their properties: colouring, flavouring, antioxidant or nutraceutical. Naturex buys raw materials all around the world and is a member of the United Nations Global Compact for its commitment to respect and promote human rights, labour standards and the environment. Naturex has a complete in-house analysis capability including equipment to authenticate the source of raw materials (HPTLC) and active compounds (HPLC, HPLC-MS, GC, GC-MS and NMR). Moreover, Naturex has a research program to validate the safety and efficacy of their products in cooperation with many universities and research centres worldwide.

Finding new botanicals

Consumers are enthusiastic for novel products and as a result manufacturers are always looking for new ideas; therefore, the ingredients industry has to bring new botanicals and derivatives to the market. The market has plenty of botanical extracts from numerous sources. However, obtaining new botanicals is a complex process that involves many alternatives. The most successful method is searching for botanicals used traditionally in other regions and adapting their consumption to a new area.

Historically, all civilizations have used botanicals to improve many health conditions. Indeed, the main part of the pharmaceutical products is based on active compounds from botanicals traditionally used for alleviating specific diseases. Unfortunately, the information on traditional use of

many botanicals is not easily accessible due to cultural and language barriers, poor research efforts in the areas of use, and even because in many cultures the traditional use of some plants is being replaced by foreign products, including drugs. The use of botanicals for alleviating diseases and improving healthy conditions is more common in rural communities, and in many cases its tradition of use is associated with underdeveloped social patterns.

If there are no written references, one of the best alternatives to find new botanicals is to start a quest through rural communities. For this mission, it is necessary to use a person or multidisciplinary team with proper qualifications in the culture, botany and medicine of the region, and a great capacity for interaction with people from these communities.

Chris Kilham, founder of the US based Medicine Hunter Inc. who works in cooperation with Naturex, is one of the most experienced persons in this field. According to Mr. Kilham, the best way to find a new botanical is through the healers. They are experienced people who keep information on traditional use of many herbs. For instance, asking to the traditional healer for a method to alleviate constipation could help us to discover a new plant for the treatment of peptic ulcers or irritable bowel syndrome. The information on cropping season, part of the plant (e.g. root, tail, leaves), and preparation is also essential to understand the correct use of the herb.

Ethnopharmacology surveys

These are another good route to finding new active botanicals. The research works published in specialized scientific magazines (e.g. Journal of Ethnopharmacology) provide an accurate picture on the efficacy of many herbs for the treatment of specific diseases (e.g. diabetes, hypertension). Moreover, this information inherently provides evidence of traditional use, which aids the adaptation of the new botanical to the

regulation of the new region where it will be commercialized. However, in spite of the enormous efforts of many researchers worldwide in the ethnobotanical field, it is likely that there are still a number of scientifically unknown plants used traditionally in rural communities.

The scientific literature on herbs from other regions also provides valuable information. There are some areas where the study of traditional plants is stronger than in the western regions. For instance, the Traditional Chinese Medicine and the Ayurvedic Indian Medicine are an endless source of active botanicals for Europe and America. There are available research works on these plants published in the local language and many others are being published in western peer reviewed journals, even though many of these plants are not yet commercialized in our regions.

Authentication, identification and efficacy

The next step involves a research programme to authenticate the origin, identify potential active compounds, and evaluate efficacy. Moreover, the assessment of potential toxicity or presence of pesticides also is also included in the programme.

As the new botanical usually is poorly known, the first priority is to guarantee the authenticity of the plant in order to continue the development. Authentication methods include macroscopic, microscopic and also some identification techniques like High Pressure Thin Layer Chromatography (HPTLC), High Pressure Liquid Chromatography (HPLC), Gas Chromatography (GC), Mass Spectroscopy (MS), and in some cases Nuclear Magnetic Resonance (NMR).

Hoodia, a novel appetite suppressant obtained from a South African cactus (*Hoodia gordonii*), is a good example of the importance to implement an authentication program. Most of the claimed Hoodia product in the US market does not come from *Hoodia gordonii*, and only through a program

of HPTLC authentication few suppliers can confirm the raw material used (e.g. HoodiaPure™, Naturex Inc.). There are some independent laboratories that help industry to authenticate new herbs providing standards and macroscopic, microscopic and HPTLC analysis services; like the US based Alkemist Pharmaceuticals Inc.

The key process in the development of a new botanical extract is the identification of active compounds. This process usually involves a mixed programme of phytochemistry and efficacy studies on *in vitro* and *in vivo* models. The first step is to identify the main molecular groups in the extract. This process includes the extraction, fractionation and elucidation of molecular compounds. Usually the chemical profile is very complex and may involve a number of compounds from the same family (e.g. silymarin) or a diversity of several compounds like flavonoids, terpenoids, tannins, saponins, alkaloids, fatty acids, amino acids, and many more.

The scientific literature provides valuable support on the efficacy of many of the identified active compounds and allows establishing a first correlation between the chemical profile and the health benefits claimed in the traditional use. Then it is possible to start evaluating the mechanism and efficacy of the botanical extract in several biological models *in-vitro*, and also *in-vivo* in human clinical trials.

Sustainable and ethical sourcing

As many of the herbs for novel botanical extracts come from rural communities, it is important to follow a responsible policy in order to guarantee the sustainability of the region. To reach this objective it is imperative to respect human rights, labour standards and the environment. A good policy in active botanicals supply allows many communities to improve their economies and use responsibly many of their natural resources.

A case study: Maca

Maca (*Lepidium meyenii*) are hypocotyls that grow exclusively between 4,000 and 4,500 meters altitude in the central Peruvian Andes and are traditionally used to enhance stamina and sexual desire (Gonzales and Valerio, 2006). Pure World Inc, a subsidiary of Naturex, opened a research programme to develop novel extracts from maca. An essential part of this program, Chris Kilham - The Medicine Hunter - found a sustainable source of maca for this project in Junín (Peru).

The research program led to the identification of two main families of active compounds: macaenes and macamides (Cui *et al.*, 2003). The fractionation of the root in aqueous and ethanolic extract allowed the development of two products oriented to enhance physical performance (MacaTonic™) and improve sexual desire (MacaPure®). MacaTonic™ has demonstrated improved endurance and reduced fatigue in an animal study (Zheng *et al.*, 2002) and improved fitness performance in a human pilot trial (Lamm and Couzens, 2003). MacaPure® has been proven to enhance sexual performance in an animal study (Zheng *et al.*, 2000) and in a human clinical trial (Padma-Nathan *et al*., 2002).

The sales of MacaTonic™ and MacaPure® have created a demand that supports many Peruvian maca farmers and provides them yearly revenue of several thousand Euro in maca purchases. Besides, with these products, Naturex has introduced Peruvian culture and history to many who would not otherwise have encountered or appreciated it.

To honour Peruvians for their discovery of maca centuries ago, Naturex granted free licences under Naturex's patents to any 100% Peruvian-owned Company in Peru who manufactures maca extract for sale to end-users. This initiative will provide further support to the Peruvian economy. In addition, the Naturex Foundation offers social development grants to Peruvian communities.

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The new nutraceuticals: ongoing projects at AFRC

By Nigel Brunton, Ashtown Food Research Centre, Teagasc, Ashtown, Dublin 15, Ireland

e-mail: nigel.brunton@teagasc.ie

With increasing awareness of the importance of antioxidants in health maintenance, their retention through food processing and storage has assumed increasing importance. Antioxidants help to prevent the occurrence of oxidative damage to biological macro-molecules caused by reactive oxygen species. Such oxidative damage, if it occurs, may be a significant causative factor in the development of many human diseases. Fruits and vegetables are good sources of antioxidants and the association between the consumption of fruits and vegetables and a decreased risk of cardiovascular disease and certain forms of cancer is supported by considerable epidemiological evidence. At Ashtown Food Research Centre we are examining the effects a number of processing methods on antioxidants in fruits and vegetables with view to developing innovative technologies to maximise the health promoting properties of processed products.

Novel processing technologies

Preservation of foods is used to inhibit microbiological contamination and to induce favourable organoleptic properties such as changes in flavour or texture. The severity of the heat processes is often reflected in the recommended shelf-life of the product. For example, canning is a relatively severe process that can often induce quality changes in the product which are at odds with consumer demands for high quality 'fresh like' products. New technologies such as *sous-vide* and high pressure processing are designed to produce a product with an extended shelf life, and the minimal processed characteristics increasingly demanded by

consumers and retailers. High pressure processing uses a transmitting fluid to apply pressures of up 1000 MPa to foods which inactivates micro-organisms and induces textural changes associated with thermal treatment. Unlike conventional cooking, these effects take place at low temperatures and, therefore, the fresh quality of the product is largely retained.

Measurement of antioxidant potential

Antioxidants exert their effect by reacting with compounds which have one un-paired electron (free radicals) thus preventing them from damaging important bio-molecules such as DNA. A number of methods can be used to quantify the antioxidant potential of a food *in-vitro* by measuring it's ability to react with a free radical. At Ashtown Food Research Centre (AFRC) we use an assay based on the loss of colour associated with the ability of the antioxidant to react with the stable free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH). The antioxidant potential of a food is then expressed in terms of it's anti-radical power (ARP) with a high ARP indicating a high antioxidant potential. We also measure levels of important antioxidant groups such as polyphenols, carotenoids and anthocyanins.

Programme objectives

Innovative technologies such as *sous-vide* cooking and high pressure processing are being used as a means of ensuring maximum retention of antioxidant compounds. The principal objective of the research programme at AFRC is to optimise technologies in order to maximise the retention of antioxidants in fully processed fruits, vegetables and their products.

Sous-vide processing

This technique involves heating vacuum packed products to an internal temperature of 90°C and holding the product at this temperature for at least 10 min. This results in product with a 12 log reduction in *C. Botulinum* giving it a shelf life of 20 days. Using the E-lab system we can

monitor both the internal temperature and the pasteurisation values of the samples as they are cooking. A pilot scale Barriquand retort (Figure 1) is used to heat the samples and the antioxidant capacity of the fruits/vegetables is then monitored over a 20 day storage period at 4°C.

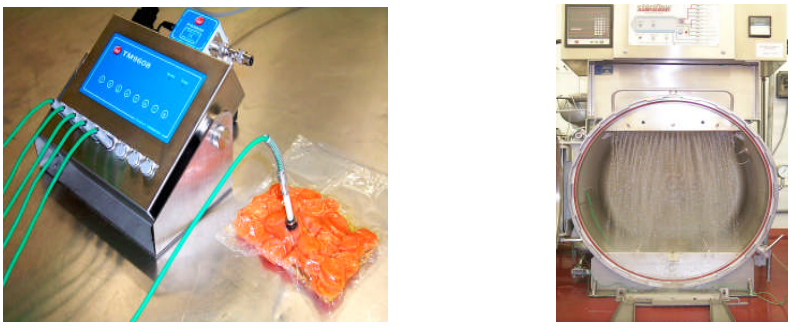

Figure 1. E-lab monitoring system and Barriquand retort for thermal processing of fruit and vegetables

Results indicate that the antioxidant potential of many vegetables (e.g. carrots, broccoli florets) decreases after *sous-vide* processing and the decrease continues during storage (Figure 2 for carrots). The effect of processing on antioxidant potential was less marked in samples heated in water to an end-point temperature of 75°C.

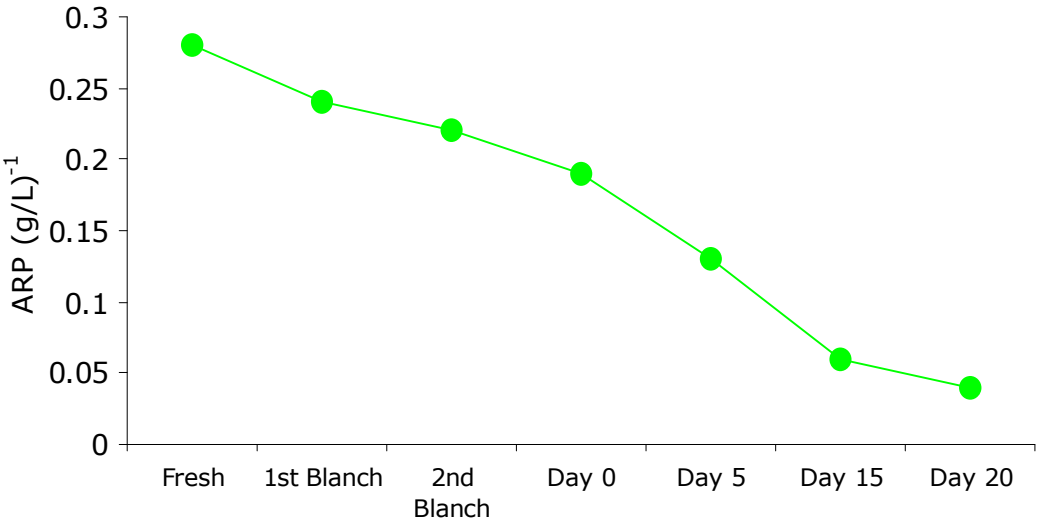

Figure 2. Antioxidant capacities of carrot disks folowing *sous-vide* processing and subsequent storage at 4°C.

High pressure processing (HPP)

HPP uses a transmitting fluid to apply pressures of up 1000 MPa to foods which inactivates micro-organisms and induces textural changes. Unlike conventional cooking these effects take place at low temperatures and,

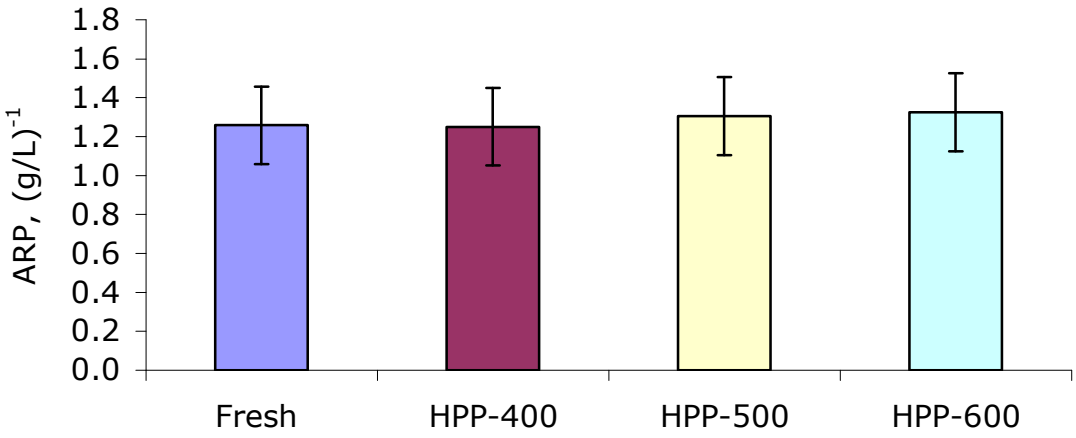

Figure 3. Effect of high pressure processing on the antioxidant capacity of strawberry purees.

therefore, the fresh quality of the product is retained. When applied to fruit and vegetables purees, HPP increases the antioxidant capacity of the purees. For example, HPP of strawberry purees at 600MPa results in an apparent increase in total antioxidant capacity as compared to fresh samples (Figure 3). The precise reason for this effect is unclear. However, it may not be due to an actual increase in antioxidant but an increase in the extractability of the antioxidants due to the fact that some types of antioxidants in foods exist in both free and bound forms. Conventional solid liquid extraction techniques will only extract free antioxidants. However, HPP appears to release bound forms resulting in an apparent increase in antioxidant capacity. This is exploited in pressurised liquid extraction which extracts higher levels of compounds than possible at atmospheric pressure.

Canning

Canning is a widely used processing technique which uses high pressures and temperatures to sterilize products giving them shelf lives of up to one year at room temperature.

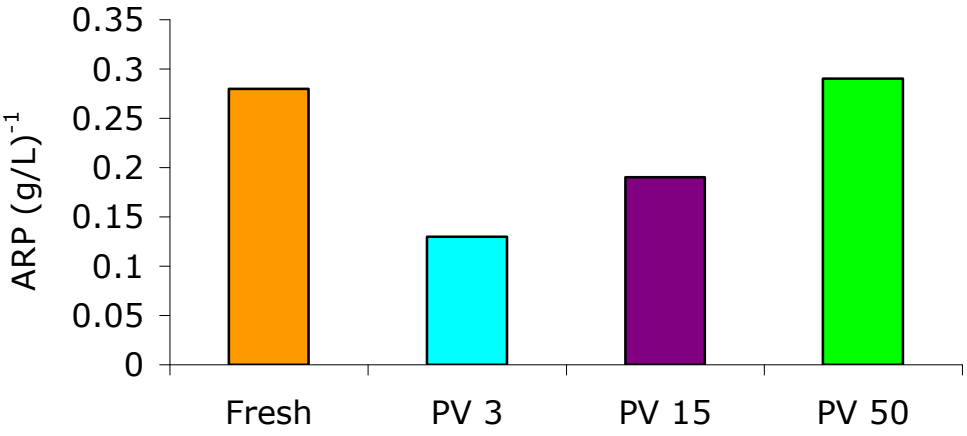

Figure 4. Antioxidant capacities of canned carrot disks processed to different pasturisation values.

Product is usually heated to a pasteurisation value of 3 (based on inactivation of *Cl. Botulinum*) in most European countries. In hotter countries products are given a pasteurisation value of up to 15 to account for higher ambient temperatures during storage. In the current studies we also included a process where samples were heated to a pasteurisation value of F^0 = 50. Canning appears to increase the antioxidant capacity of carrots and the more severe the process the higher the antioxidant capacity (Figure 4). This appears to be counter intuitive. However, Maillard reaction products can form at higher temperatures. These have been shown to have potent antioxidant capacities and thus their formation could account for the higher antioxidant capacity.

Conclusions

There is a complex relationship between processing and antioxidant capacity in foods. Studies at AFRC have shown that while a decrease in the antioxidant capacity may come about as a result of thermal processing, heating to high temperatures can result in the formation of compounds with antioxidant activity (e.g. Maillard reaction products). However, the effect of storage on antioxidant capacity appears to be more straightforward with significant decreases occurring over time regardless of storage temperature.

Ashtown Food Research Centre (AFRC) is one of the research centres of Teagasc which is an Agriculture and Food Development Authority in Ireland. For more information see www.ashtownfood.ie/preparedfoods

Functional ingredients addressing glycaemic impact of white bread

By Pat Burton, PhD., Ashtown Food Research Centre, Teagasc, Ashtown, Dublin 15, Ireland.
e-mail: pat.burton@teagasc.ie

Introduction

The role of carbohydrates in health and disease has received a high profile in recent years and this has led to the development of the glycaemic index (GI) as a physiological classification of carbohydrate foods, in terms of blood glucose-raising potential of such foods, following ingestion (Ebbeling *et al.*, 2003). Recent data support the preventative role of a low-GI diet against the development of type 2 diabetes and cardiovascular disease (Salmeron *et al.*, 1997). There is also an interest in the potential of low GI diets in body weight management, acting through reduced hunger and, subsequently, reduced food intake. Importantly, both the quantity and quality of carbohydrate in the diet play a critical role in obesity and co morbidities.

In developed countries, the food industry processes some 80% of consumed foods and consequently, one challenge to the food industry is the provision of a wider range of low GI foods (Bjorck & Elmstahl, 2003). A low-GI food is defined as having a GI of ≤ 55, a medium-GI food one with a GI ranging between 56 and 69, and a high-GI food having a GI of ≥ 70 (Aston, 2006). This has particular relevance to the consumption of bread, a common carbohydrate source. Modern treatments of starch-

based foods incorporate the generation of a number of forces, such as shearing, compression and extreme heat treatment, upon the starch granule, facilitating more readily the important process of starch gelatinisation. One example of this is the adoption of roller milling of bread flour and abandoning of earlier stone milling practices in the nineteenth century, leading to a relatively greater damage of the starch granule. Together with ongoing development in the bread-making process, this has led to a highly favoured white bread, but of relatively high GI value and low satiety (fullness) value. Thus white bread, in particular, is an important target carrier-matrix for functionality, with respect to new ingredients or reformulation, delivering reduced glycaemic impact.

The GI per se is defined as the incremental area under the blood glucose response curve (IAUC) of a portion of a test food, expressed as a percentage of the response to an equi-available carbohydrate amount of a standard (reference) food, taken by the same subject, on a different day (WHO/FAO, 2003; Wolever, 2006). The principle is that the slower the rate of carbohydrate absorption following the ingestion of carbohydrates or carbohydrate-containing foods, the lower the rise in blood glucose level and the lower the GI value. Indeed, high GI foods are characterised by fast-release carbohydrates and higher blood glucose levels. Thus, the GI, illustrated in Fig.1, reflects the quality of carbohydrates and ranks sources of carbohydrate according to glycaemic responses determined using equi-available carbohydrate amounts.

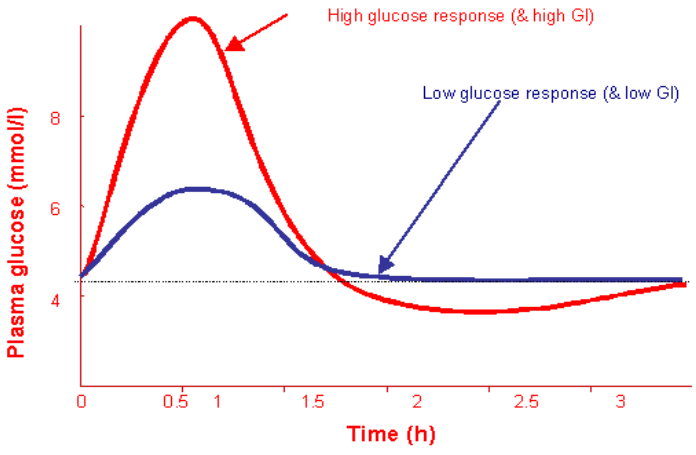

Figure 1: Glycaemic responses to high GI and low GI foods

Available and unavailable carbohydrate: the ambiguity of dietary fibre

It is important to note that the GI refers to the glucose-raising potential of the "available" carbohydrate component of a carbohydrate food, with the intended exclusion of the unavailable, non-glycaemic carbohydrate portion. However, there has been a transition from consideration of the unavailable carbohydrate moiety as dietary fibre alone, to the inclusion, for example, of resistant starch (RS), modified starches, polydextrose and sugar alcohols; thus, the glycaemic concept has become more complicated. The lack of consensus over many years regarding the carbohydrate components which should be included as dietary fibre has highlighted also the need for a working definition of dietary fibre per se, and increased emphasis has been placed on the primary characteristic "resistance to digestion" (Lunn & Buttriss, 2007). It has been recently highlighted that glycaemic control is more strongly correlated with unavailable CHO than with GI. Therefore, a new and significant focus on the role of unavailable carbohydrate in glycaemic improvement is emerging.

The Glycaemic load (GL)

Related to the GI classification of carbohydrates or carbohydrate containing foods is the concept of glycaemic load (GL), a product of the food's GI and the dietary carbohydrate content per serving (g), i.e. a measure of the glycaemic response to the total amount of ingested carbohydrate. Though the GL can be reduced either by reducing the quantity of CHO intake or by reducing the GI, there appears to be some controversy over the validity of GL as a measure of overall glycaemic response. In terms of bread consumption, lowering the GI, by changing the formulations of breads habitually consumed, would be a useful nutritional manoeuvre in terms of functionality of this staple food, with implications in health and disease.

Glycaemic Glucose Equivalents (GGE)

One alternative measure to GI and GL for characterizing the glycaemic impact of food is the glycaemic glucose equivalent, GGE, defined as the weight of glucose having the same glycaemic impact as a given weight of food (Fig. 2). GGE content thus predicts glycaemic impact of foods over a range of practical carbohydrate intakes and, as such, has been claimed to be more useful to the consumer. Thus, in relation to the consumption of the highly-favoured white bread, it is portion size – or intake – sensitive.

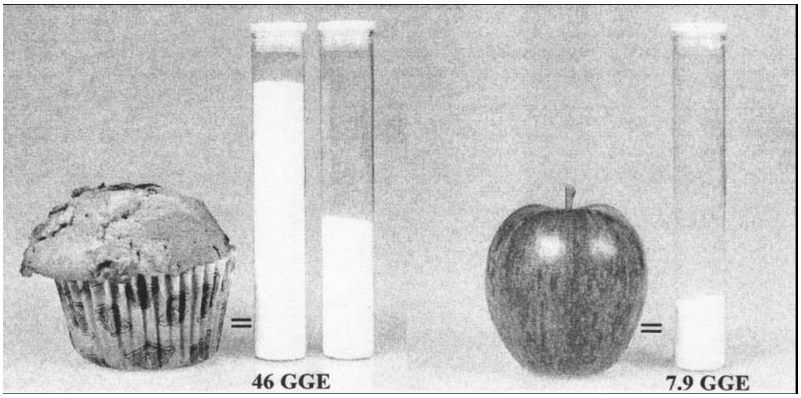

FIG. 2. Glycaemic impact expressed as a glycaemic glucose equivalent (GGE) intake. The GGEs of sweet muffin and apple are 46 g and 7.9 g glucose respectively (Monro & Shaw, 2008)

Importantly, a preferred use of GGE, as an alternative to GI, has been recently highlighted, within food tables (Livesey *et al.*, 2008). This is important for future effective labelling of glycaemic data in the provision of guidance towards healthy dietary choices. Essentially, the glycaemic impact of a food may be communicated through GGE in an identical way as other food components, as grams per serving and as grams per 100g of food (Monro & Shaw, 2008).

Food factors affecting glycaemic response

A number of factors have been shown to influence the glycaemic response to carbohydrate foods, and in relation to bread, these include the structure of the starch component, the incorporation of resistant starch, the degree of starch damage through food processing, food form and

particle size, the inclusion of whole kernels, viscous fibres and organic acids. The addition of oat bran, as a source of soluble fibre, reduces the glycaemic response to wheat products. Accumulating research evidence has demonstrated reduced glycaemic response with the addition of organic acids, such as acetic, propionic and lactic acids, to bread mixtures, thus mimicking sourdough fermentation (i.e. the traditional French bread making process, which is regaining popularity throughout Europe in the artisan market).

Application of our understanding of the many food factors affecting glycaemic response is seen in the range of available commercial breads with a variety of intact seeds, such as sunflower, sesame and pumpkin, of which there are an increasing number on our supermarket shelves. These seeded / grained breads have their important niche but are not suitable for, or preferred by, all consumers, such as the elderly (McKormack, 2006; 2007).

The development of techniques of manipulating / modifying starches for specific purposes has important application for the baking industry. For instance, the formulation of bread made from flours of relatively high amylose content, such as maize, will result in higher gelatinization temperatures and a greater propensity to retrogradation, which in turn relates to the resistant starch (RS) content of bread varieties. Moreover, viscosity, mouth-feel, appearance and texture, are examples of food qualities to be targeted by manipulating functional properties of breads.

Opportunities for the baking industry: substitution of high glycaemic ingredients with low glycaemic and nonavailable carbohydrate alternatives

The use of flour of cereals other than wheat in bread making, used by either blending with wheat to make what is referred to as "composite flour", or as the sole cereal component, also offers great potential for increased functionality in terms of glycaemic impact. Moreover, it has been highlighted that the nutritional quality of bakery products may be improved by replacing the relatively inferior wheat grain flour in this

aspect with non wheat flours, protein products of other cereals, tubers, corn gluten, corn germ and rice bran. There are a variety of alternative flours to wheat available to the baker, such as rye, corn, oats, and rice and, in addition, flours from cereal-free grains, such as potato, amaranth and quinoa. The principle challenge of production of bread from composite flour, viz. a blend of wheat flour with flour of other cereals is based on the fact that the non wheat flour acts in diluting bread quality; this dilution effect is dependent on the degree of substitution and on the strength of the wheat flour in the composite. Moreover, the challenge of manipulating white bread formulations, will limit our choice of flours alternative to white wheat, with focus on maintaining the favoured and unique sensory characteristics of white bread.

Composite flours are currently used, for instance, in Zambia and Zimbabwe, with 6% and 10% maize flour substitutions respectively. It has been reported that 25% maize flour can be mixed with 75% wheat flour without appreciable difference in the quality of the composite bread. In the context of reduced glycaemic impact, maize porridge has been shown to have a lower *in vitro* starch digestibility in comparison with white wheat bread (van der Merwe *et al.*, 2001); (Zhang *et al.*, 2006). In contrast, other studies have shown no difference in the glycaemic response to maize in comparison with white wheat bread (Shula *et al.*, 1991). The mechanism by which glycaemic response may be reduced in breads made with high-amylose maize has been suggested to be due to the increased RS content of these breads (Muir *et al.*, 1995; Champ, 2004) and, importantly, modified maize starches have been incorporated into cereal foods, including breads, with resultant glycaemic responses.

An additional ingredient receiving recent research attention has been “stabilised rice bran”, a nutrient-rich and cholesterol-lowering agent (Hegsted *et al.*, 1993). Bread made from rice flour has offered a positive alternative to wheat bread, for example, for patients with inflamed kidneys, hypertension and in coeliac disease, due to its relatively low sodium, protein and fat contents. Rice “bran” is produced in the second

stage of milling, where the outer brown layer of (brown) rice is removed from the brown rice kernel. It is unusual in that under normal conditions, a degradation reaction takes place between a lipase and oil in the bran, to free fatty acids and glycerol, resulting in the bran becoming unpalatable (Prakash, 1996). This explains the common usage of rice bran in animal feed rather than for human consumption for many years. However, new techniques of stabilization of the rice bran after milling, consisting of short-term high-temperature treatment, which destroys the lipase activity, have been developed. A relatively recent study has demonstrated acceptability of 24 foods containing defatted rice bran as a dietary fibre source, important in dietary adherence or good reception of new foods by consumers (Schorle *et al.*, 2003). Full-fat and defatted rice brans have been used in bakery products, breakfast cereals and wafers as a protein supplement and as beverage bases (Prakash, 1996). In bread formulations, the addition of either forms have resulted in loaves of acceptable volume (Lima *et al.*, 2002). Rice bran and fractions are also high in antioxidant activity and have been shown to significantly reduce hyperglycaemia and hyperlipidaemia. Substitution of varying levels of wheat flour with these components into the preferred white bread with the intention of reducing postprandial glycaemic excursions are of merit to explore, particularly since the addition of rice bran to breads has been demonstrated to increase the nutritional profile (Kadan & Phillippy, 2007).

A programme of research at Ashtown Food Research Centre in Dublin is examining how the glycaemic impact of white bread may be reduced through substitution at varying levels with flours such as maize and rice bran, pseudocereals such as amaranth and resistant maize starches (Fig. 3). An *in vitro* starch hydrolysis assay developed at the Campden and Chorleywood Food Research Association Group, based on the methods of Brighentii et al (Brighenti *et al.*, 1995), is being modified. *Hydrolysis response* values will be indicative of glycaemic impact of the entire food, (bread portion) as well as a *hydrolysis index*, indicative of the glycaemic index of potential low-GI bread formulations.

Figure 3: White wheat bread substituted with maize flour and rice bran fractions.

Conclusions

In the context of the high consumer preference for whiter, softer bread formulations, a specific challenge for the baking industry is the provision of a wider range of white breads of reduced glycaemic impact, avoiding the sensory properties of wholegrain bread varieties or low-GI varieties containing intact seeds and kernels. What is important is that relatively small differences in the glycaemic potency of regularly consumed starch foods have been shown to have beneficial effects on health. Considering the high consumption of white bread, novel white bread formulations as functional foods in terms of deliverance of reduced glycaemic impact will lead to increased accessibility to these important health benefits, with the potential of contributing to the prevention and management of glucose intolerance, insulin resistance and associated chronic disease.

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Functional ingredients: how much should we add to foods?

By Birgit Niemann, Federal Institute for Risk Assessment, Berlin, Germany
See: http://www.bfr.bund.de/

Recently, several models have been developed to calculate safe maximum amounts of vitamins and minerals for the purpose of food fortification. However, none of the models include the adding of bioactive ingredients to foods. At present, the number and variety of bioactive substances used as functional food ingredients is growing rapidly.

Parameters of the models

All existing models are based on the idea that the difference between a safe threshold for a chronic intake and a high nutritional intake percentile of a certain micronutrient could be distributed to a variety of common foods. The commonly used threshold is the so-called Tolerable Upper Intake Level (UL). This value corresponds to the total chronic daily intake of a nutrient (from all sources) judged to be unlikely to pose risk of adverse health effects in humans. ULs are based on generally accepted scientific data related to a nutrient, with emphasis on human studies. In recent years, ULs have been established by authorised expert committees for most of the vitamins and minerals. Authorised expert committees are the Scientific Panel for Dietetic Foods, Nutrition and Allergy of the EFSA

(NDA panel) and its precursor SCF in Europe and the Food and Nutrition Board of the Institute of Medicine (FNB/IOM) in the US. Threshold values were also proposed by national nutritional expert bodies.

In some of the models the maximum amount is calculated based on the energy content of the foods, but in other models the portion size has been chosen as reference. Further differences result from the consideration of supplement use, from the included percentage of fortifiable foods, from subgroup-specific intake data, and from the classification of nutrients according to their risk potential. To date, none of the models is an established part of a legal framework. Currently, the European Commission encouraged a discussion process to derive maximum amounts for micronutrients in the context of the regulation on the addition of vitamins and minerals, and of certain other substances to foods (1925/2006/EC).

Functional Ingredients

Is the approach mentioned above applicable to functional ingredients? There is no simple answer to the question. The model may be used for substances that are biologically essential or have an undoubtedly demonstrated health impact.

Bioactive substances used as functional ingredients are an extremely diverse group of chemicals including complex mixtures and microbes. Commonly used ingredients are synthesised or isolated substances from plants and other living systems and include plant sterols, carotenoids, phytoestrogens, polyphenols, oligosaccharides, special fatty acids or derivatives of amino acids. Furthermore, extracts from tea, spices, herbs, food plants and traditional medicinal plants from all over the world are used as functional ingredients. All these substances are normal constituents of our daily diet in low and/or trace amounts. Unlike micronutrients, functional ingredients are not regarded as essential for human nutrition, which means they do not cause deficiencies. The consumption of bioactive substances is associated with a benefit for consumers' health, which is, however, rarely based on scientific evidence. Foods containing functional ingredients are advertised with so-called health claims to communicate the supposed benefit for provoking

consumers' interests in buying. Therefore, the addition of bioactive ingredients to foods leads to a healthy image for the functional product and triggers an increase of functional products in the food market. Another point of concern is health claims that cover statements about physiological functions or special indications based on a dose-response relationship between a substance and a measurable physiological effect. In this case, the single advertised food must contain the effective dose of the functional ingredient to avoid misleading consumers, even if the amount in the single food is beyond known nutritional intake.

Anyway, the health claim-driven extension of functional ingredients raises the potential for a high intake of bioactive ingredients among consumers and could elicit a stealthy development of undesired effects if consumed in high amounts over long periods. After all, for most of these ingredients there is no history of safe consumption for amounts that are significantly above the levels found in human diets. Moreover, the work for deriving Tolerable Upper Intake Levels for substances, other than vitamins or minerals, is still to be done.

Do we actually need Tolerable Upper Intake Levels for functional ingredients?

With a view to healthy human physiology, this question can only be answered with – yes. The surprising increase of the lung cancer rates among smokers and asbestos workers found in the last decade of the 20th century in the large intervention studies on cancer prevention with the antioxidant nutrients Vitamin A, ß-Carotene, Vitamin E and Selenium (ATBC and CARET) taught us that epidemiological associations between dietary intake of a substance and the risk of disease could not only be insufficient but also misleading. Since that time, the verification of epidemiological findings by intervention studies in large populations over longer time periods is recognised as indispensable. More recently, this cognition was confirmed by comparable experience with folic acid used for the secondary prevention of colon cancer in a clinical intervention study, where higher numbers of serious lesions in the folic acid group were found.

Looking for alternative solutions

In the midst of rapid growth in using bioactive substances as food ingredients and the immense scientific work that has to be done for deriving ULs for all the substances, we should look for alternative solutions. For instance, maximum amounts for the addition of bioactive substances to foods could be deduced on the following considerations: (a) as daily food consumption is limited, the variety of ingested foods and the consumption amount for each food should be in an inverse relationship. Therefore, the daily intake of a food ingredient should reach a steady state at a defined number of fortified foods containing the same amount of the substance in one typical daily consumption amount of the carrier food; (b) As the habitual intake of foods represents the most reliable history of safe intake in large populations, and over long periods, the highest observed habitual intake (HOHI) of the substance of concern could be used as long as there is no established UL.

Analysis of the consumption data of the first National Food Consumption Study in Germany (NVS 1986-89) with more than 23,000 participants showed the following results: On average, people consumed 22-25 of approximately 340 available food types per day (without water, tea, coffee and alcoholic drinks); 95% of the population consumed up to 40 food items and only very few people ate more than 60 different food items over one day. A worst case simulation study showed: On condition that a typical serving size of 40 different food types will be fortified with a fixed amount of a functional ingredient, 90% of the population would consume up to seven functional foods per day. The other 10% would ingest eight to 15 food items of the functional products. The average intake of the functional ingredient in the population increases in the form of a satiation curve that stagnates at 10 ingested fortified foods. In consideration of the fortification strategies on the food market, numerous food items of the product groups spreads, cereals, dairy products, bread & other bakery products, cheeses and sausages, fruit and vegetable juices and soft drinks as well as snacks and ice cream have been among the 40 simulated functional food types.

In conclusion----

A simple strategy to derive reasonable amounts of functional food ingredients could be the follows: **(i)** the substance has to be characterised and all traditional foods containing it have to be determined; **(ii)** the population with the highest habitual intake of these foods has to be selected for calculating the intake of the substance; **(iii)** the highest identified habitual intake could be divided by a factor of 10 to consider the multiple exposure by all the other food commodities containing the same ingredient. The resulting amount could be added to one serving size of a given food product. ***However, this approach cannot be used for functional foods claiming dose-related effects that require amounts beyond all nutritional experience.***

Linseed fractions as functional ingredients

By Matti Sepponen, Linseed Protein Finland Ltd, Teknologiapuisto 1, 61800 Kauhajoki, Finland
matti.sepponen@linseedprotein.com

Flax has been used as a food and textile fibre source for over 5000 years. It has been known as a medical plant which can be used for stomach disorders, wounds and skin problems. Nowadays we still agree with this and its many healthy components, and especially the linseed fraction, give large possibilities for developing new functional and healthy food products. The Latin name of linseed, *Linum usitatissimum,* means "very useful" and the plant has many applications. Linseed is a good source of dietary fibre (including soluble dietary fibre), alpha-linoleic acid, phyto-estrogens, antioxidants and lignans, and has a known laxative effect.

Processing

Traditionally linseed has been processed by oil pressing and the products obtained from this process are linseed oil and the press cake. However, new gentle fractionating technology has been developed recently, and the

purpose of this process is to obtain the valuable components in as pure and clean form as possible thus avoiding oxidation of the easily-oxidised linseed oil. This process has opened new potential and frontiers for a new generation of linseed fractions.

Linseed fractions

Soluble fibre: The seed coat contains natural polysaccharides at a level of about 5% of the total seed weight. The main sugars of this soluble fibre fraction are xylose, rhamnose, galactose, arabinose and fucose which form different arabinoxylans. This "linseed gum" has a very high water binding capacity and also strong emulsifying properties which makes it useful for texturizing food. There are some published studies indicating that soluble linseed fibre may lower the glycaemic index of ingested foods and inhibit cholesterol uptake; however, additional studies are needed to confirm these findings. Traditionally linseed mucilage has been used to help stomach functions, especially constipation.

Protein: Linseed contains about 20% protein. All the essential amino acids are present and the nutritional value of the seed is good. Recent studies have shown that some linseed protein peptides have ACE (angiotensin I-converting enzyme)-inhibiting activity indicating that they have the potential to lower blood pressure. A protein concentrate and an isolate from linseed can also be used for texturizing food products, binding fat and improving foaming.

Lignans: One of the most signifiacnt bioactive compounds of linseed is lignan (SDG) and linseed is among the richest known sources of lignan. Adding milled seeds, pressed cake or linseed husk fraction to foods affords an excellent opportunity for developing new functional food products. The list of possible/potential health effects is long, ranging from menopausal problems to prevention of hormonal cancers and osteoporosis. The lignans are situated in the fibrous husk fraction of the seed and are accompanied

by other health benefiting components such as polyunsaturated fatty acids and insoluble fibres. Lignans are quite stable under processing conditions, for example baking, which is good news for processors. However, consumer awareness of lignans is poor relative to other health promoting constituents such as PUFAs. This imbalance needs to be redressed as lignans have a major positive role to play in preventive medicine. This should be publicised and would help greatly in launching of new products enriched with lignans.

Polyunsaturated fatty acids: Linseed oil is well known because of its high content of alpha-linolenic acid. In Finnish varieties, levels of omega-3 fatty acids are exceptionally high amounting to almost 60% of the total fatty acids. In practice, the use of oil or press cake in food products is not straightforward. The oil oxidises quickly and this may cause taste problems. One possible solution is to use microencapsulated oil in powder form. Another is to use de-hulled seed kernel, where the oil is still well protected inside the cell matrix.

Product applications

Many product applications for linseed fractions are published in the technical and patent literature. For example, linseeds can be ground, steam-treated, matured to reach a pasty state, and extruded and re-ground. This material is then mixed with cellulose and/or starches to give an excellent functional ingredient which has particular application in bakery products. Whole linseeds are often a constituent of bakery flour mixes in some countries and also of mueslis.

Production of linseed fractions

Linseed Protein Finland Ltd has developed new range of linseed fractions, which are designed for helping food companies to add functional properties into many different food product concepts. The company is starting up its first full-scale production plant during 2007 after extensive

technological development work. The main products are *LinoFibre*–soluble linseed fibre; *LinoProt55*-protein concentrate; *LinoHusk*-lignan-rich fibre product; *LinoKernel*-seed kernel with over 50% oil content. *LinoFibre* has a good water binding capacity and emulsifying properties. It improves texture and gives the end product a better, thicker and juicier structure; it has been successfully tested in various food applications. *LinoProt55* has an excellent amino acid profile containing all the essential amino acids and is a good source of glutamine. It has good foaming and film forming properties thus enabling it to form emulsions. Functional properties can be influenced by using a mixture containing *LinoFibre*. *LinoProt* can replace, for example, soy bean or milk proteins. *LinoHusk* has a mild, grainy taste thus making it suitable for various food applications such as bakery products, processed meat products, milk-based products, ready-to-eat products, food supplements, breakfast cereals and snack products. *LinoKernel* is suitable for many different applications including bakery products, processed meat products, milk-based products, ready-to-eat products, food supplements, breakfast cereals and snack products.

More information

Personnel at Linseed Protein Finland Ltd are very willing to share their knowledge of application possibilities with customers who are interested in these new ingredients. Please visit the company website at www.linseedprotein.com or contact the managing director Matti Sepponen; matti.sepponen@linseedprotein.com

Pectin as a dietary fibre

By Regina Lüthi, Obipektin AG, Industriestrasse 8-9220 Bischofszell, Switzerland
e-mail: R.Luethi@obipektin.ch

In recent years we have seen the introduction of a variety of new and innovative ingredients, which offer functional capabilities that may help to prevent a number of diseases and conditions ranging from weight loss to cardiac disease and cancer prevention. Some of these ingredients have gone on to be used in a number of popular products within the market place, while others have quickly faded into obscurity. In the end, it is the customer who finds the advantages in a product, and the more confusion there is with an ingredient, the less desirable a product is to customers. Here, dietary fibre offers an advantage that many new innovative products cannot match. The term dietary fibre, both soluble and insoluble, and its associated health benefits are well known by the average consumer.

During the last 20 years, fibre intake has been declining steadily to a current level of about 20g per day. This is much lower than what is recommended, which can be as high as 30g per day. Dietary fibre is an essential part of a healthy diet and refers to a group of food components (cellulose, hemicellulose, lignin, pectin, gums). It passes through the stomach and small intestine undigested and reaches the large intestine virtually unchanged. Pectin is a dietary fibre and presents a unique opportunity to manufacturers looking to easily increase the quality and health-profile of their products. While pectin is more commonly regarded as a gelling agent, thickener, emulsifier, stabiliser or fat/sugar replacer, it does contain dietary fibre and can contribute significantly to dietary fibre intake.

Soluble fibre

This has, at least, three important properties. Firstly, it can act as a sugar modulator. The swelling and water sequestration prevent rapid absorption of sugar into the bloodstream and are an obvious advantage for both weight control and diabetes. Further, adding to its function as a weight control agent, dietary fibre and soluble fibre in particular, have been shown in many studies to increase satiety. It does this by bulking-up food and binding water leading to a feeling of satiety in a natural way. Finally, certain soluble fibres can help in lowering blood-cholesterol levels. While the exact mechanism is unknown, it is thought to be closely related to the way it regulates the slow absorption of nutrients. It is for the above mentioned reasons that dietary fibre is of such high interest. More and more, final products are advertised as "high in fibre" or "natural source of fibre". Pectin is present in many natural products and is permitted as an ingredient in many others. Until now, pectins are most often used for their application properties and not as dietary fibres.

Pectin HM Ultra Low Viscosity (ULV)

This was developed by Obipektin AG, to add both soluble fibre and the application advantages of pectin to a final product. The pectin contains 80-90% soluble fibre and is easily integrated into many different applications. A key benefit of Obipektin's 'pectin HM ULV' is that it is stable during heating and storage in acidic beverages at pH-levels around 3, giving manufacturers greater confidence that there is no degradation and that the amount of soluble fibre added is the amount that can be labelled. Furthermore, pectin from fruit has a neutral taste which makes it 'partner well' with other constituents in beverages. Pectin gives volume and body to a drink avoiding the typical flat taste associated with many diet drinks. Pectin can improve the mouth-feel, which is extremely important due to the potentially lower sugar content in diet drinks.

Pectins as stabilisers

As mentioned above, pectins can also be used for stabilisation, for example in acidified dairy drinks, where it protects milk protein from coagulation. Acidified dairy drinks – mixtures of milk-products with fruit-juice - are a good source of protein and calcium, but also rich in vitamins and other nutrients. In acidified dairy drinks, however, the milk protein needs to be protected from coagulation. Pectin can prevent this by absorbing onto the protein-molecules thereby preventing them from sticking together and precipitating. Fruit-acidified soy drinks are also becoming more popular. They can be 100% vegetarian and offer health-benefits from soy that are increasingly recognised. Adding a low-viscosity soluble fibre in the form of specialised pectins to these products, creates additional potential health benefit for the consumer.

Obipektin: products and advice

In total, Obipektin offers over 100 different pectins, each standardised to a specific application to meet manufacturer's needs. With this level of specialization, it is easy to find the right pectin to add mouth-feel, stabilisation and fibre to an application, i.e. as pectin experts, Obipektin can easily provide the right ingredient for any application. Our dedicated pectin technical and application laboratory is there to help food companies with their needs, ranging from selecting pectin for a particular application, to labelling and nutritional aspects.

Natraceutical Group

Obipektin is part of the Natraceutical Group, which includes Overseal Natural Ingredients located in England and the Spanish company Natraceutical. With the growing need for healthier products, Natraceutical group offers major opportunities in product development. It produces a large number of recognised ingredients, well accepted among manufacturers and consumers. These can be easily adapted to many

applications to add dietary fibre to products and contribute to consumer health.

Soluble cocoa fibre is the first ingredient with a high content of soluble fibre derived 100% from cocoa. As a natural source of fibre, it contains all the previous mentioned health benefits. Beginning with cocoa powder containing 4% soluble fibre, Natraceutical has increased its concentration to 40% while maintaining the natural character of cocoa in the final product. Soluble cocoa fibre also has a low fat content, i.e. approximately 2.5%, making it very suitable for low fat products. Soluble cocoa fibre may be used in a variety of applications, where an increase in soluble fibre content is required.

Natraceutical Group uses only high standard raw materials and emphasises sustainable agriculture in all projects. They have implemented technological and management practices on cocoa plantations that reduce cost, preserve quality, and protect both health and the environment. Natraceutical Group uses mainly Ghanaian cocoa beans, which are preferred Worldwide because of their high quality, and also cocoa beans from the Ivory Coast, the World's largest cocoa producer. This ensures high quality and constant supply. Natraceutical Group provides all the necessary ingredients to help create tomorrow's healthy foods, today.

More information from Natraceutical Group, Plaza América 2-9ª planta, 46004, Valencia – Spain www.natraceuticalgroup.com **or** from R.Luethi@obipektin.ch

β-Glucans and cereal soluble fibres: their role in functional foods

By Mark Lawther, Biovelop A/S, Biovelop A/S Hejreskovvej 18A 3490 Kvistgård, Denmark.
e-mail: lawther@biodevelop.com

Introduction

With urgently renewed interest in "eating for health" in the developed world, alongside the endemic obesity problem, much activity is focused on delivering soluble fibres to the consumer via the food industry. The "western" diet is overall fibre deficient, especially so for beneficial soluble fibres. Whole-grain cereals are obvious and major sources of healthy soluble and insoluble fibres in Europe and have huge potential to fill the "health gap" provided they are presented to the consumer in *palatable* form. It is a reality that all consumers should eat whole grain and bran on a daily basis. However, it is equally apparent that many will not do so. There is, therefore, a consumer and market drive to supply healthy ingredients derived from cereals that retain functional characteristics, but have little of the taste or "roughness/dryness" normally associated with cereal brans. Such soluble fibre rich ingredients emanating from oat, barley and rye grains can then be used in a whole range of foods commonly consumed in the western diet, impacting very positively on health and well-being.

Oats and barley grains

These are rich in the soluble fibre known as beta glucan. Rye grain is rich in another type, arabinoxylan. These fibres impart a number of health benefits to the consumer if consumed in sufficient quantities. These include improved gut condition and health, cholesterol reduction, and slower glucose absorption in the small intestine ("GI" effect). The soluble fibres are located mainly in the sub-aleurone, aleurone and bran parts of the grains. The best known cereal soluble fibres from a functional food standpoint are beta glucans, and so the main focus here is on oat beta

glucan. However, it should be noted that high molecular weight arabinoxylans from Rye are also very interesting viscous soluble fibres and deserve to receive serious attention from the food industry.

Biovelop A/S, Denmark, has developed and patented a process to produce a fraction of oat bran rich in beta glucan. The product is marketed and sold as **PromOat™.** This is a white powder containing 33-35% beta glucan, which dissolves to form a viscous solution. The product's solubility, lack of colour and neutral taste mean that it can be used in a number of fine food formulations to both boost soluble fibre levels and perform thickening and stabilizing functions within the foodstuff. The product is manufactured in Sweden by a sister company, Scandinavian Oat Processing AB.

Oat soluble fibres and health benefits

Soluble fibres, in balance with insoluble fibres, perform important roles in the digestive tract and are essential for maintenance of a healthy colon wall and colonic environment, being available for fermentation by "good bacteria" (pro-biotic microbes), and as such exert pre-biotic effects. Soluble fibre-based pre-biotics are becoming increasingly important as health-promoting functional foods (1). Soluble fibres are mainly polysaccharides (e.g. beta glucans, arabinoxylans, plant gums) and oligosaccharides (e.g. fructo-oligosaccharides). These soluble materials are not digested in the human stomach and small intestine and survive mainly intact into the colon, at which point they are available for microbial fermentation, as briefly described. In addition, ***viscous soluble fibres*** (i.e. mainly high molecular weight polysaccharides) also have very important functions in the small intestine in that they generate high viscosity in the digest mass and help lower serum cholesterol, and also modulate glucose flow and absorption, impacting on the glycemic index or GI of the food consumed (2,3).

Oat beta glucan is such a viscous soluble fibre. Other pre-biotic soluble fibres, such as inulin and fructo-oligosaccharides, do not fit into this category as they are relatively low in molecular size.

Chemically, oat beta glucan is a mixed linkage (1→3), (1→4)-β-D-glucan, and is a linear, homopolymer (polysaccharide) of glucose with interesting solution and rheological properties (4). The β-linkages in the polymer chain render the beta glucan non-digestible and, therefore, a soluble fibre. The cholesterol-lowering effect associated with ingestion of oat beta glucan has been recognized for several decades. Numerous clinical trials (5, 6, 7) have demonstrated the efficacy of oats and oat brans and enriched oat bran fractions in this respect, the beta glucan component being the active ingredient. Such is the knowledge base that the FDA in the USA have allowed a health claim which confirms the positive effects of consuming oat soluble fiber on the reduction of risk of coronary heart disease in humans (8). The practicality of the ruling leads to a requirement to supply 3g oat beta glucan per day, on a maximum four portion per day basis for a given food preparation. This means that each portion must contain at least 0.75g of oat beta glucan. Similar health claims are now allowed in the UK and in Sweden, with the "0.75g per serving" concept being the key. It is also now recognised that the beta glucan should not be degraded, but retain substantial solution viscosity and molecular size to function correctly in this respect.

Functionality in food systems: building functional foods containing oat soluble fibre

Beta glucans are high molecular weight soluble polysaccharides and are interesting *natural* hydrocolloids and *functional ingredients* in their own right. *Clean label* beta glucan rich preparations from oat bran can be used to achieve the following properties in food formulations:

- Viscosity
- Texture

- Creamy-mouthfeel
- Fat replacement
- Enhanced water–binding
- Emulsification (stabilization of the aqueous phase)

At relatively low-levels of addition (0.25-1%), oat beta glucan engenders a full-fat, creamy mouth feel to low-fat preparations, giving a degree of body to the food. It is particularly interesting in reduced fat sauces wherein an indulgent mouthfeel is wanted. Indeed, fat-replacement is an excellent starting point for use of beta glucan in foods. The low or reduced-fat message is recognized and positive. Fat-replacement is, therefore, also the way to introduce beta glucan into a functional food formulation. As oat beta glucan thickens and emulsifies water/oil mixes, it can be used to produce and stabilize reduced fat mayonnaise and dressing emulsions. Levels of addition in these cases are between 1.5–3% of the dressing. Again, this is a functional, low-fat application. At these levels of addition the food producer can think about the labels "added fibre", "contains oat fibre" or variants on these themes, as well as "reduced fat".

To consider claims based on maintenance of healthy serum cholesterol levels, there is the FDA guideline (also adopted in some EU countries, e.g. the UK) which states that each "portion" of foodstuff upon which the claim is made must contain a minimum of 0.75g of oat beta glucan. This means oat flours, meals and oat bran fractions rich in beta glucan can be formulated into food products to deliver the required dosage. The term "portion size" is the key. A drink has a portion size of 200 ml. This implies an addition of 0.75 g beta glucan to that portion, or 0.375% of the formulation. The same in a soup, whether powdered for make-up to 200 ml, or ready liquid. This is relatively straightforward. Likewise, the portion size of baked "morning goods" such as bread rolls, muffins etc, varies between 80-120g; therefore to consider making a claim, 0.5-1% of the formulation should be oat beta glucan. A proportion of this could be added

as fat replacer, the remainder as a moisture binder or conditioner. However, in the case of a product such as a margarine spread, the portion size is 14g and the addition of 0.75g viscous beta glucan is more problematic in such a system. The message is: select the correct food system with a portion size that can accommodate 0.75 g of oat beta glucan, which binds water and imparts viscosity and mouthfeel to products. Positively use the properties of the beta glucan within the formulation. In many cases it will usefully replace other functional (e. g. hydrocolloids, starches, flours, protein) parts of the recipe.

Oat beta glucans are also excellent in fruit smoothies and engender a creamy mouthfeel and body to the drink. A 200 ml smoothie is a perfect way to deliver the recommended dose for a claim. This also applies to related drinks where "mouthfeel" is expected.

Ready-meals are a further example and are ideal carriers for functional ingredients. There is an increasing trend for time-conscious consumers to buy ready-made meals that can be warmed and consumed. These should taste good, but also be healthy and nutritious. This offers exciting possibilities for the food formulator to include healthy oat beta glucan soluble fibre in the diet of the busy westerner. Beta glucan can be added to potato mash (creamy mouthfeel), pasta, reduced fat sauces (fat-replacer and creamy mouthfeel), to a reconstituted meat product (moisture binder and fat-replacer), to a batter coating (pre-dust or in the batter mix), in a bread bun, as part of a spoonable dessert, or in a drink. From such a list (which is not exhaustive), it is possible to construct ready-meals which can be:

- Reduced fat and clean-label/natural
- Containing added fibre/soluble fibre/oat fibre
- Cholesterol beneficial (i.e. reduction)
- Medium (or low) GI

- A combination of some, or all, of the above.

The manufacturer will be able, in theory, to select the appropriate labelling in line, of course, with local and/or EU rules and guidelines. As already highlighted, to consider a cholesterol related claim, there must be at least 0.75g oat beta glucan (maybe 1.5g) in the meal (is it 1 or 2 "portions"?). However, in a 350g ready meal, this is a small overall percentage and is readily achievable. In most of the meal components, the food producer will have used the thickening, rheological, water-binding or related properties of beta glucan to enhance the quality of the food, as well as enabling selected health claims to be made.

In summary

Soluble fibres from cereal grains, particularly *viscous soluble fibres* such as oat beta glucans, offer great potential in functional foods. Their interesting functional properties, such as thickening and stabilizing, emulsifying and water-binding effects can be utilized in a number of food formulations such as sauces, dressings, drinks, desserts and ready-meals to give good, indulgent mouthfeel, emulsion stability, and body. This in turn leads to foods enriched in soluble fibres, which are inherently healthier for the busy consumer. Depending on the levels of addition of soluble fibres (such as oat beta glucan) into the product, manufacturers can consider attaching recognized claims to the products.

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Contact Details: *Mark Lawther, Research Director; lawther@biodevelop.com*

Algal calcium: filling the nutritional gap means eating well – supplement naturally & 'BONE' APPETIT!

By David O'Leary, Marigot Group Ltd, Strand Farm, Currabinny, Carrigaline, County Cork, Ireland

e-mail: d.oleary@marigot.ie

A natural solution to the problems of bone health is close at hand. Aquamin™ a plant derived, calcium rich, multi-mineral form of nutrition is known to be highly effective in addressing the growing concerns of osteoporosis and joint health across all age groups. Marigot Ltd, the producer of Aquamin™ has been investigating their unique source of marine mineral nutrition in clinical research. Much application research in mainstream food products has shown that this is an easy product to incorporate in a multitude of formulations and recipes. Several grades of Aquamin are available depending upon application type.

Osteoporosis in the EU

In the EU, it is estimated that an osteoporotic fracture occurs every 30 seconds (1). Osteoporosis is a 'silent' disease of the skeleton which is caused by low bone mineral density and leads to fragile bones that are susceptible to fracture. Today, osteoporosis shockingly strikes one in three women and one in five men at some stage in their lives (2), but with a shift in demographics towards an ageing population, the number of people affected is expected to increase. The World Health Organisation has indicated that the number of osteoporosis related fractures may rise to 6.26 million in 2050 compared to 1.66 million in 1990 (3). In short, osteoporosis is rapidly gaining notoriety from a public health perspective with EU officials now recognising that this disease needs to be halted in its tracks before it is too late (4). The frustrating thing about osteoporosis is that it is a highly preventable disease, yet despite the efforts of many groups such as the International Osteoporosis Foundation at educating

people on prevention, osteoporosis marches on. Why is this so? Is it because we see osteoporosis as being a disease of the elderly and, therefore, do not act early enough to build our defences?

Battling osteoporosis

The battle against osteoporosis should commence at an early age and one of the best defences is to ensure that we build strong bones as we develop into adults. During the World Osteoporosis Day held on October 20th 2006, much focus was placed on the importance of diet in preventing osteoporosis under the "Bone Appetit" theme. Particular attention was placed on calcium and Vitamin D, and on their dual role in achieving optimum bone health. In the EU, the RDA for calcium and vitamin D is 800mg and 5mg, respectively, but their actual intake falls far short of this recommendation resulting in a nutritional gap that has serious consequences for our bones. Vitamin D is principally made in the skin following exposure to sunlight but can also be obtained, albeit at lower amounts, from oily fish and eggs. Vitamin D is responsible for controlling the amount of calcium absorbed from the intestine into the blood and also controls the re-sorption of calcium from the kidneys; both are key steps that ensure blood levels of calcium are tightly regulated. Any drop in this calcium level can have serious consequences for our bones because in order to maintain the tight regulation of calcium in our blood, the bone acts as a calcium reservoir and readily gives up calcium thus leaving a deficit.

Strong bones

In bones, calcium along with phosphate forms hydroxyapatite, the inorganic matrix that determines bone strength or density. In order to have strong bones, it is essential to eat enough calcium as 'we are what we eat'. The ideal ratio of calcium to phosphorous in the diet is 2:1. Good sources of calcium are dairy products, green leafy vegetables and bony fish such as sardines. Alternatively, calcium can be sourced through

supplements of fortified foods such as bread, cereal and soy products. Ensuring that we have an adequate intake of calcium from an early age will help obtain peak bone mass as we develop and maintain it as we age. Interestingly, it is estimated that at a population level, a 10% increase in peak bone mass could reduce the risk of osteoporotic fractures in adult life by as much as 50% (5).

Consumer awareness

Consumers are progressively growing more aware of the link between diet and disease prevention. Yet despite this, when it comes to bone health, there is still a nutritional gap between what is recommended and what we actually consume. If we put this nutritional gap in perspective for vitamin D and calcium, the principal sources of both are sunlight exposure and dairy products, respectively. It is well established that too much sun exposure greatly increases the risk for skin cancers as a result of damage by harmful UV radiation. Similarly, dairy products have seen a downturn in consumption in recent years as a result of the demand for low fat/zero fat foods. The established link between milk lactose and the medical condition of lactose intolerance in Europe and North America has also contributed to the downturn. While some aspects of the nutritional gap can be justified for health reasons, others such as avoiding calcium sources due to their fat content are more unwarranted. Nevertheless, there are plenty of options in the form of (a) alternative foods (fish oils, eggs), (b) supplements for vitamin D and also in the form of fortified foods, and (c) supplements for calcium which if consumed should bridge the nutritional gap that is affecting our bones.

Choosing a supplement

When it comes to choosing a supplement, a good choice is one that is scientifically proven to have a positive impact on bone health. When we enter a pharmacy, we see a myriad of supplements on the shelf. However, with a little forward thinking we can make the best choice for our bones.

Supplements should be well tolerated and have proven bioavailability. Marigot Ltd produces the natural multi-mineral complex Aquamin™. This is rich in bio-available calcium and magnesium, and is backed by good science and testing. Aquamin™ is a natural plant-derived multi-mineral complex that is found in the unpolluted Atlantic waters off the south-west coast of Ireland. Aquamin™ impacts positively on bone mineral density. The portfolio of scientific investigation behind Aquamin is growing with many clinical studies completed and pending peer review. Marigot are confident that this product will deliver on many levels and will address concerns of diet, body acidity, osteohealth and joint mobility. Aquamin™ also contains other important bone forming minerals such as zinc, manganese, copper, silicon and boron which have been scientifically proven to have a positive effect on bone density (6). Aquamin™ can, therefore, more than adequately close the calcium gap and is nature's choice for a natural defence against osteoporosis.

Marigot Ltd specialise in the development and production of natural mineral products for use in foods, nutraceuticals, dietary supplements and cosmetics. Using calcified seaweed as its primary raw material source, the company produces the Aquamin™ range of products. Aquamin is a natural marine mineral with unique functional and nutritional properties. It is an organic mineral source derived from mineralised seaweed, *Lithothamnion Calcareum*. Aquamin is rich in calcium (approximately 34%) along with over 70 other minerals and trace minerals.

For further information contact: Marigot Group Ltd, Strand Farm, Currabinny, Carrigaline, Co. Cork, Ireland.

Tel: +353 21 437 8727; Fax: +353 21 437 8588; E-mail: marigot@indigo.ie

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Enhancing the content of beneficial fatty acids in beef and improving meat quality for the consumer

By Nigel Scollan, Institute of Grassland and Environmental Research, Aberystwyth, Wales
e-mail: nigel.scollan@bbsrc.ac.uk

"Enhancing the content of beneficial fatty acids in beef and improving meat quality for the consumer" (EU Healthy Beef)) is the title of an R&D project funded under the EU fifth framework "Quality of Life and Management of Living Resources" programme. The project commenced in November 2000, was completed in 2004, and focused on the lipid composition of beef.

Meat is inherently functional and fat in meat provides essential fatty acids and vitamins to the consumer and plays a critical role in the sensory perception of juiciness, flavour and texture. However, there is a perception among consumers that red meat, in particular beef is a food with a high fat content and is considered to contribute towards certain human diseases because of the belief that it has a high proportion of saturated fatty acids. Departments of Health in a number of countries have recommended a reduction in the intake of saturated fats and an increase in the intake of

unsaturated fatty acids, and in particular the omega-3 polyunsaturated fatty acids (*n*-3 PUFAs), because they are known to be beneficial to human health. These factors have provided an impetus to develop strategies to alter the total fat concentration of beef, and the fatty acid composition of the fat, to be more compatible with consumer requirements.

Fat content of beef

The fat content of beef varies with the choice of cut or beef product, the animal (genetic) and the production system. The fat may be present as intermuscular fat (between the muscles), intramuscular fat (marbling, *ie*. within the muscles) and subcutaneous fat (under the skin). Most of the fat is present as triglycerides but phospholipids, cholesterol and fatty acid esters are also present. The beef industry has made excellent progress in reducing the fat content of beef as a result of changes in breeding and feeding practices and modern butchery techniques. Across a range of studies it was noted that marbling fat concentrations range from 20-50 g/kg (Figure 1). This lean beef could be considered as a low fat food.

Fatty acid composition of beef

Intramuscular fat typically consists of approximately 47, 42 and 4% of total fatty acids as saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and PUFA, respectively. Of the total SFA, 30% are represented by stearic acid (C18:0) which is considered neutral in its effect on plasma cholesterol in humans. The PUFA in beef contains considerable amounts of *n*-3 PUFAs, particularly α-linolenic acid (C18:3*n-3*) and the longer chain PUFAs, eicosapentaenoic acid (EPA; C20:5*n-3*) and, docosahexaenoic acid (DHA; C22:6*n-3*). Beef contributes significantly to the intake by humans of EPA and DHA, of which there are few rich sources apart from oily-fish. These fatty acids are not incorporated into triacylglycerols (storage fat) to any significant extent in ruminants. Outcomes from EU Healthy Beef have shown that these fatty acids are mainly found in membrane phospholipids and hence predominantly in

muscle. This is important since it provides the opportunity to alter intramuscular fatty acid composition of beef without increases in fatness *per se*.

Two important nutritional indices are used to describe the fatty acid composition of foods. The first is the ratio of PUFA: SFA, the P:S ratio, and the second the ratio of the *n*-6:*n*-3 fatty acids (usually expressed as the ratio of essential fatty acids C18:2*n*-6 (linoleic acid) : C18:3*n*-3 (linolenic acid). The P:S for beef is typically low at around 0.1, except for double muscled animals which are very lean (<1% intramuscular fat) were P:S ratios are typically 0.5-0.7. Results from EU Healthy Beef have demonstrated a strong relationship between total intramuscular fat content and P:S ratio (Figure 2). The ratio of *n*-6:*n*-3 ratio for beef is beneficially low, typically less than 3 and the focus has been on methods of increasing the P:S ratio and lowering the *n*-6:*n*-3 ratio by increasing the content of beneficial *n*-3 PUFA.

Important sources of dietary fatty acids

The most important method of manipulating the fatty acid composition of beef is by changing dietary ingredients, which are known sources of long chain PUFA. These include forages and a range of oils and oil seeds. Grass is an important feed source for beef animals in the UK and it is beneficial that the main fatty acid in grass is α-linolenic acid, approximately 60% (Figure 3). Oilseeds differ widely in the fatty acid composition of their lipid but usually one fatty acid is predominant. Rapeseed, soybean and linseed are rich in oleic, linoleic and linolenic acids, respectively, and feeding animals on these products generally results in increases in the corresponding fatty acid in the product (i.e. the beef). However, the way in which the lipid is offered to the animal can have a major effect on the degree of response, for example, as the oil or whole oilseed. Fish oils are rich in the long chain PUFAs, EPA and DHA.

Feed effects on fatty acids in beef

Feeding grass in comparison with concentrates (based on barley, molasses, soya) increased the proportions of *n*-3 PUFA (C18:3*n*-3, C20:5*n*-3, C22:5*n*-3 and C22:6*n*-3) in the intramuscular lipid of *longissimus dorsi* muscle (Figure 4) and also reduced the proportion of saturated C16:0. It is noteworthy that feeding a diet rich in the "building block" for the *n*-3 series, C18:3*n*-3 not only increased C18:3*n*-3 in beef muscle, but also the longer chain EPA and DHA. This response to grass feeding is time dependent. Typical P:S and n-6:n-3 ratios for grass feed beef are 0.1 and 1.5, respectively.

Linseed is also a rich source of α-linolenic acid and when included as part of a concentrate feed, then in similarity with grass feeding, it increases the content of *n*-3 PUFA in beef muscle and reduces *n*-6:*n*-3 ratio. However, in most studies to date it has proved difficult to significantly increase the P:S ratio.

Rumen metabolism and use of ruminally protected lipids: Research from EU Healthy Beef has confirmed the extensive degree of lipolysis and biohydrogenation of dietary lipids in the rumen. Biohydrogenation of dietary C18:2*n*-6 and C18:3*n*-3 is high, typically 80-92% and so the beneficial changes noted when feeding grass or linseed result from only small amounts of these fatty acids appearing at the muscle. Biohydrogenation is the main reason why it is difficult to have major positive shifts in the P:S ratio. However, the use of ruminally protected lipids (PLS), which allow unsaturated fats to bypass the rumen has a very beneficial effect on P:S ratio (Figures 5 and 6). This highlights the role of the rumen in manipulating dietary fatty acids and helps understand the mechanisms of lipolysis and biohydrogenation.

Breed effects on fatty acids in beef

Breeds may also differ in the fatty composition of beef i.e. dairy *v*. traditional beef animals. Comparisons of Holstein-Friesian *v*. Welsh Blacks

indicated that total muscle fatty acids were higher in Holstein-Friesians than Welsh Blacks. The content of EPA was 20% higher in Welsh Black. When expressed as a proportion of the total fatty acids, *n*-3 linolenic acid as well as EPA was higher in the Welsh Black, resulting in improved P:S and *n*-6:*n*-3 ratios.

Effects on meat appearance and flavour

Altering the fatty acid composition of beef can affect meat quality by providing a different mix of reactive ingredients in the beef, which affect oxidative stability (shelf life), colour and flavour. Increasing the levels of PUFA in meat may sometimes lead to accelerated colour changes from red to brown while grass feeding in comparison with concentrates enhanced *n*-3 PUFAs in the meat, reduced the oxidative changes during retail display, and slowed colour deterioration. This was related to the delivery of beneficial α-tocopherol (vitamin E) from the diet through to the meat.

Fatty acid composition of muscle lipids has important consequences for meat flavour, because lipid degradation products such as aldehydes, participate in the flavour forming reactions which occur during cooking. For example, fish oil increased the EPA and DHA contents and gave the greatest oxidative lipid changes in meat. This coincided with generally negative comments on odour and flavour from a taste panel. However, in comparison, taste and appearance were good in meat derived from animals fed on concentrates containing linseed, with a high concentration of α-linolenic acid and medium levels of EPA and DHA.

Conclusions

The results from the EU Healthy Beef project assist the development of novel systems of producing beef with improved nutritional value in terms of fatty acids, thus providing a healthier quality product for the consumer. The results also further the understanding of the interactions between fatty acid composition of beef and other aspects of meat quality such as shelf life and flavour. Beef can be produced that is low in fat, has a lower

concentration of atherogenic SFA, higher MUFA and PUFA concentrations, higher P:S ratio and lower *n*-6:*n*-3 PUFA ratio than was possible previously. Current and future research of the team seeks to further enhance the fatty acid profile of beef. This includes communication with consumers and health professionals on the importance of meat as part of a healthy balanced diet.

More information

Contact: Nigel Scollan nigel.scollan@bbsrsc.ac.uk
and see http://www.healthybeef.iger.bbsrc.ac.uk/

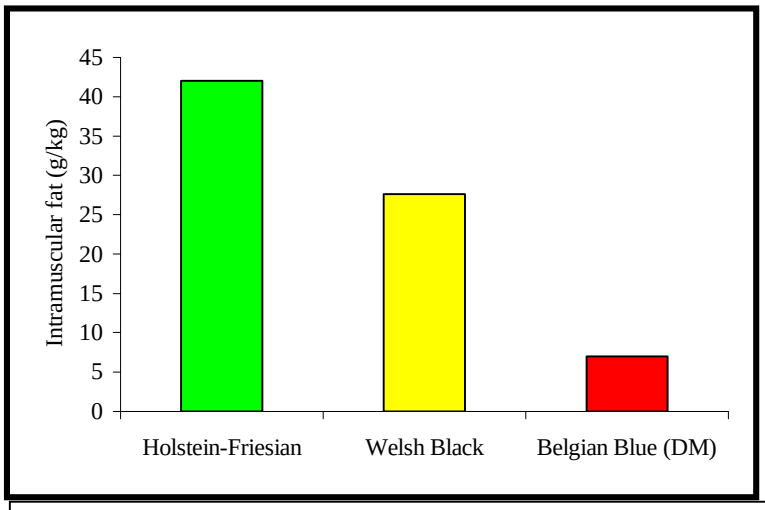

Figure 1: Intramuscular fat (g/kg) in beef

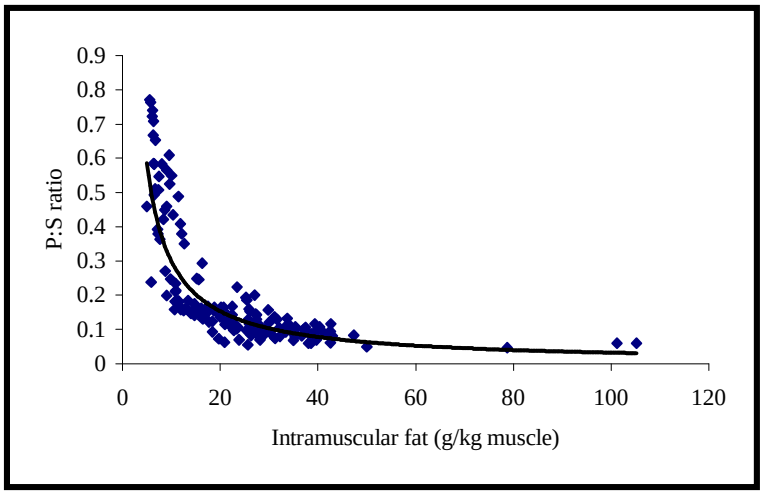

Figure 2: Relationship between intramuscular fat content and P:S ratio

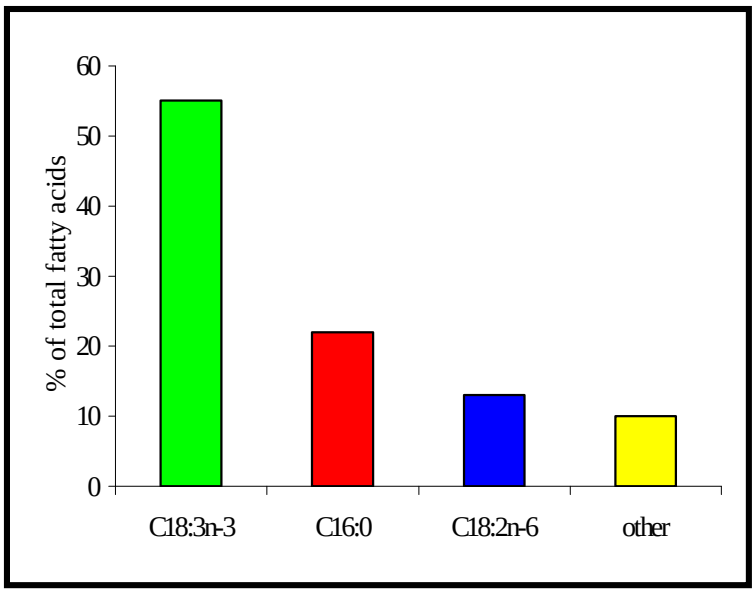

Figure 3: Fatty acid composition of grass

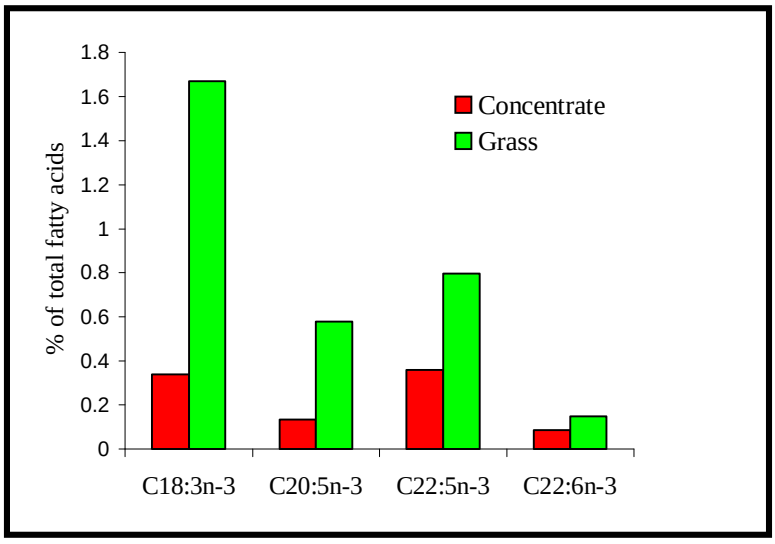

Figure 4: Effect of concentrate versus pasture feeding on fatty acid composition of *longissimus dorsi* muscle

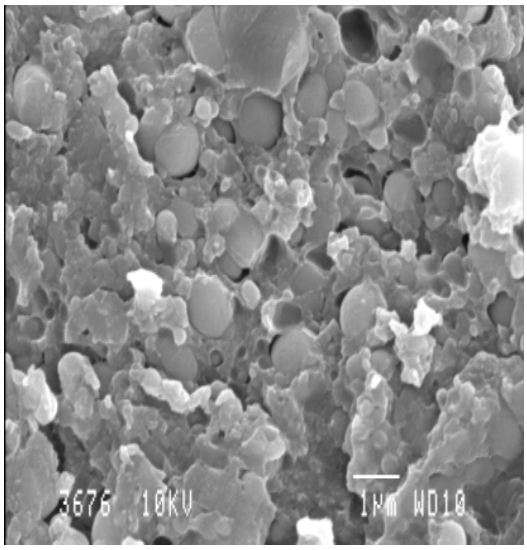

Figure 5: An electron microscopy image of the ruminally protected lipid supplement

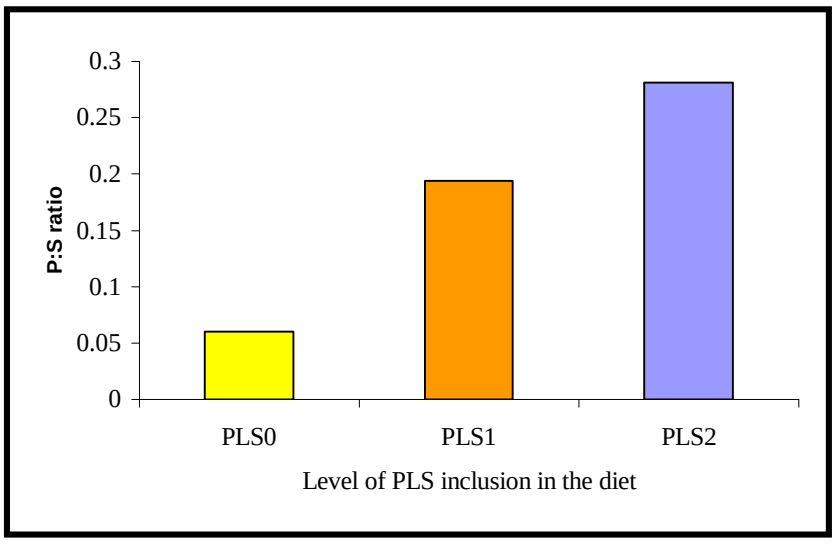

Figure 6: Effect of feeding a ruminally protected lipid supplement (PLS)

New insight: Clarinol™ CLA helps overweight and obese people lose fat where it matters most; a decrease in abdominal fat promotes health and well- being

By Henk Zwier, Lipid Nutrition
e-mail: Henk.Zwier@lipidnutrition.com

Conjugated Linoleic Acid (CLA) is an extensively studied, natural ingredient that is used for more than 10 years in nutritional supplements to help reduce body fat and increase muscle mass. Recent evidence shows that CLA decreases fat mass especially in the legs and abdomen. Now, with abdominal obesity becoming an increasingly important health issue globally, there's never been a better time to start offering food products with CLA that provide such body weight management benefits.

Obesity is a major health problem with a high prevalence

Obesity can be defined as the excessive accumulation of fat to the extent that health may be impaired. Especially when the fat accumulates in the abdomen it is associated with increased risk for cardiovascular disease, hypertension, stroke, diabetes and certain forms of cancers. The most widely used measures of total and abdominal fatness are body mass index (BMI) and waist circumference. Obesity is now a global public health problem, with about 315 million people world-wide estimated to fall into the WHO-defined obesity categories with a body mass index (BMI) of 30 or above (1). Obesity is a chronic disease associated with numerous complications, with serious social and psychological dimensions, affecting virtually all ages and socioeconomic groups. It ultimately can cause death and the numbers are frighteningly high. For instance in the US, it causes 300,000 deaths annually. Therefore, it is essential to develop strategies to prevent weight gain or obesity. In the light of the ever increasing obesity epidemic conjugated linoleic acid (CLA) is an effective natural ingredient as demonstrated in several human trials. In combination with a healthy diet and exercise CLA seems to work most optimally. A recently conducted

human trial with Clarinol™ CLA substantiates its healthy effects in an overweight and obese population.

A wealth of evidence

In 1987, Prof Mike Pariza from the University of Wisconsin discovered that CLA had biological effects (2). He isolated CLA from beef and found that CLA prevented tumour formation and thus had anti-carcinogenic effects. After its initial discovery, CLA has been extensively studied. Since 1987 numerous other beneficial effects have been demonstrated like the effects on cardiovascular disease, inflammatory diseases, diabetes, osteoporosis and body composition (3). Especially the latter finding boosted the research on CLA at the end of the last century. Nowadays, once every two days a new CLA study is published in peer-reviewed scientific journals. In total, more than 1400 scientific papers on CLA have appeared since 1987. As a result, a large body of evidence exists on the weight management effects of CLA in animals and humans. Of all the ingredients aimed at optimizing body composition and weight maintenance, CLA is the best researched and documented. A meta-analysis of studies by renowned institutes clearly confirm that CLA can play a role unrivalled by any other ingredient on the market today in producing desired results in terms of weight maintenance, improved muscle mass and body shaping (4).

Latest scientific evidence demonstrates that Clarinol™ CLA reduces fat mass where it matters most

Lipid Nutrition, who produce the highest purity of CLA currently available on the market, have been working with CLA since the early 1990s. The company's research activities have significantly contributed to what is known today about CLA and its application possibilities, and led to the development of the Clarinol™ products. Recently, Lipid Nutrition initiated a large scale, randomized, double blind, placebo controlled trial with 118 overweight and obese persons (BMI of 28-32 kg/m^2) which was conducted by independent research centres in Norway (5). This clinical study clearly

showed that Clarinol™ significantly reduced body fat mass by about 2 kg which corresponds to 6 % of the body's fat mass for the CLA group when compared to the placebo group. Reduction of the fat mass was located in regions of the body where it matters most: in the legs and the abdomen. Waist circumference was reduced by 2 cm and as a result the waist/hip ratio was also decreased in the CLA supplemented group. Lastly, body weight and BMI decreased too. A common side effect of weight loss is loss of muscle mass. However, CLA preserved or even slightly increased muscle mass which is another beneficial effect of CLA. Individuals, especially women, with the highest BMI responded best to CLA. Furthermore, this trial also demonstrated that both young and old adults seemed to respond equally well to CLA. In the context of the ageing population this latter finding is important, because ageing tends to result in fat gain and loss of muscle mass which CLA seems to counteract. Thus in summary, this study shows that CLA supplementation for 6 months in healthy, overweight and obese adults affected body fat mass in specific regions of the body, increased lean body mass and was well tolerated.

Going mainstream

CLA is naturally present in the average human diet via foods such as milk, beef, cheese and yogurt, but at levels that are relatively low. Clinical human studies have shown that it's possible to reduce weight and improve overall body composition simply by increasing the quantity of CLA in one's diet. Clearly, this provides manufacturers with a great new source of untapped market potential, given the growing public concern with weight, health and wellbeing. There are, however, some issues to address in order to create CLA-enhanced foods that will truly appeal to consumers. Until now, CLA has followed the same evolution as other functional ingredients. Initially, they were only available as supplements in specialized outlets, such as chemists and drugstores, and used by a small, dedicated group of highly health-conscious individuals. The next phase is integrating the ingredients into specialty products, such as nutritional bars

and shakes. But only by going one step further and getting the ingredients into products on supermarket shelves is there true potential to reach a mass market and achieve large-volume sales. This is the point at which CLA is now.

Suitable for foods, beverages and dietary supplements

The purity and composition of CLA is crucial. CLA preparations highly enriched as in Clarinol™ are preferable for human consumption in terms both of efficacy and safety. Clarinol™ is available in free fatty acid (FFA) form as well as triglyceride (TG) form, and is suitable for use in a wide variety of applications, from dietary supplements to foods and beverages. As a soft gel capsule, both forms of Clarinol™ can be used and it is recommended taking Clarinol™ together with a meal, such as lunch or dinner.

In food, an appealing application would be to include Clarinol™ in a one shot milk or fruit drink that can be consumed in between meals or just prior to a meal. Another interesting concept is to include Clarinol™ in meal replacers, such as bars and ready to drink (RTD) beverages. Of course, numerous other applications are also possible. With Clarinol™, Lipid Nutrition has not only come up with a powerful weapon in the fight against obesity, but has also provided a versatile and desirable ingredient that will help food and dietary supplement manufacturers extend their ranges and expand their markets.

Worldwide, more than 1.3 billion people are overweight. The obesity epidemic is recognized by the World Health Organization as one of the top 10 global health problems and one of the top 5 in developed nations. In the face of this global problem, industry, governments, doctors and scientists have all been looking for ways to combat obesity. There is clearly a market for Clarinol™ CLA as a food additive or dietary supplement to help tackle this increasing threat to people’s health.

Lipid Nutrition and Clarinol™ CLA

Lipid Nutrition B.V. holds globally a strong position in weight management products with PinnoThin™ appetite suppressant and Clarinol™ CLA. Next to weight management, Lipid Nutrition offers a variety of branded products like Marinol™ highly concentrated fish oils (EPA/DHA and DHA) for heart health and brain development, and Betapol™ human milk fat replacer for better fat and calcium absorption in infant nutrition.

Lipid Nutrition B.V. markets scientifically sound, natural, lipid ingredients which improve and maintain health and wellbeing. The company also provides expert advice and assistance regarding the application, processing, laboratory analysis, marketing and legislation of functional ingredients and their products. This makes it possible for customers to get the most of the market possibilities and potential that functional ingredients offer.

Clarinol™ CLA oils and powders in the Lipid Nutrition range offer the highest and purest concentration of the beneficial active isomers (c9,t11 and t10,c12) of any CLA product on the market today. Clarinol™ CLA was the first to be granted self-affirmed GRAS (Generally Recognized as Safe) for food products, and can be used in a wide variety of applications. These include dairy products, margarine spreads, salad dressings, baked goods, and frozen or shelf-stable plate meals containing meat, fish or poultry.

MORE INFORMATION www.lipidnutrition.com
www.Clarinol.com

Lipid Nutrition

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Functional food design: the role of *in-vitro* biomarkers

By Lluís Arola, Technological Centre of Nutrition and Health, Reus and the Rovira i Virgili University, Tarragona, Spain

E-mail: lluis.arola@ctns.cat

When technologists, scientists or entrepreneurs consider the possibility of designing a functional food from the products they work with, they have to answer several scientific and technological questions. They must ask themselves the right questions in order to determine which bioactive substance they wish to use, e.g. how can it be introduced into the food matrix without disrupting the organoleptic characteristics; which probiotic they wish to use; how they can remove certain molecules from the food; which dose can they use, etc. Above all, however, they must know which

pathological process they want to impact on and which mechanism they will use.

Pathological processes can only be monitored with biomarkers, which are signs that indicate whether the bioactive substance or the probiotic that is being used really has any effect on the development of the pathology. Biomarkers are commonly used in medicine to detect and monitor pathological processes. They are usually plasma—but sometimes tissue—parameters, which reflect the homeostatic situation and indicate the functional disorder of the organism. For example, high levels of triacylglycerols in plasma are one of the first indicators of dyslipidemia.

Using clinical biomarkers in the design of functional foods is not easy, even though they play a major role in their success. Biomarkers need to be clear signs of the pathological process and they also need to be assessed and used throughout the process of manufacturing a food. The first difficulty lies in the fact that it is not possible, for obvious reasons, to use humans in the process. Only after sufficient experimental evidence has been found can intervention studies in humans be considered to confirm the efficacy of the new food.

Neither is it correct or economically viable—because of the cost and the length of the experiments—to use experimental animals for *in vivo* studies. Of course they must be used before intervention studies are carried out in humans, but it is not a useful model for the design phase of a new food. Therefore, *in vitro* models have to be used.

In vitro models

Cell suspensions, cultured cell lines or any of the current techniques that make it possible to reproduce the real conditions of an organism *in vitro* are appropriate for the purpose. Of course problems need to be extrapolated and solved but, with greater or lesser difficulty, valid experimental solutions can be found. For example, how can the transformations undergone by the substances under study in the gastrointestinal tract be reproduced? The substance administered is often

not the same as the substance that actually reaches the cells so its effect may not be the same. One possible solution is to administer the substance to experimental animals, obtain plasma and then use it to treat the cells; another is to simulate the digestion processes in the laboratory. The best solution needs to be found for each case, and experimentally this is possible.

Finding a biomarker

Once a valid experimental model has been found, the second difficulty is to find the biomarker that can be used *in vitro* to simulate the *in vivo* homeostatic situation. Finding good indicators that are fast and that are usable in the various phases of the food manufacturing process puts the ingenuity of the scientists to the test.

Biomarkers can be used *in vitro* in three possible ways. The first, which is similar to the end-point biomarkers that are used *in vivo*, is to use the quantification of a particular molecule as a biomarker. This approach has many difficulties: which molecule under *in vitro* conditions can clearly indicate that a pathological process that occurs *in vivo,* with the whole organism functioning, is improving? This question is usually not easy to resolve and sometimes it is impossible. On occasions, however, quick and useful solutions can be found: for example, the determination of the cell oxidation state can be a good indicator of the oxidative stress but not a real indicator of the direct effect that the substance under study has at the biochemical or physiological level. Very often the use of this strategy excessively simplifies the information obtained and leads to wrong decisions being taken. Sometimes, however, it is the only strategy available to functional food manufacturing companies.

Dynamic cellular processors

The second way is to use dynamic cellular processes as biomarkers. *In vitro* it is methodologically possible and relatively simple to evaluate how metabolic pathways and cellular processes work, and this enables appropriate biochemical and/or physiological information to be obtained so

that better decisions can be taken. Taking dyslipidemias once again as an example, it is relatively simple to administer radioactive acetate to cultured hepatic cells, and evaluate the *de novo* synthesis of triacylglycerols and cholesterol, and their secretion from cells. Much more information is provided this way than merely by quantifying the cell levels of these metabolites, so the taking of decisions in an attempt to prevent or ease dyslipidemia with functional foods is facilitated.

This dynamic approach is useful for some pathologies; however, it is not sufficient to fully clarify the action mechanisms of the potentially bioactive molecules and it is not useful in complex pathologies either. This is why new methodologies are being used that provide an overall vision of the biochemical changes induced by bioactive molecules. Fortunately, current "omic" techniques (transcriptomics, proteomics and metabolomics) provide an overall vision that avoids the information loss of the other two approaches and at the same time improve understanding of the biochemical mechanisms that determine the presence in the cells of the substances under study. In a cell model, after a particular substance has been administered, it is possible to see the modifications to the expression of all the genes, and the changes in all the protein and metabolite concentrations. This means that we have complete information, which enables us to reliably interpret the biochemical mechanisms that intervene in the molecular actions that we wish to study.

"Omic" methodologies

These have made great strides in recent years and, although there is still much to be done from a methodological point of view, nowadays it is more straightforward to acquire all the information on which to base decisions than it is to interpret the information and take the decisions! Biological complexity often means that the three methods described need to be integrated in order to take really useful decisions about the design of functional foods. Likewise, an overall focus such as the one mentioned above makes it much easier to sustain any claims of functionality because it provides the scientific evidence on which these claims are based.

Helping food companies

There is, however, an obvious problem: neither the dynamic nor the overall approach is available to those companies interested in producing functional foods. In this respect, strategies need to be found that make it possible for companies to access advanced biochemical methodologies.

One example of such a strategy is to be found in Catalonia: the Technology Centre in Nutrition and Health is being set up on the Reus campus of the Rovira i Virgili University, the public university in Tarragona. The mission of this centre is to develop strategies and methodologies so that companies can have a scientific base for their claims of functionality, and new functional foods can be designed. The aim, therefore, is to provide companies with those methodologies that enable *in vitro* studies to be carried out with dynamic and overall approaches. The Technology Centre in Nutrition and Health, then, aims to provide companies interested in manufacturing new functional foods with *in vivo* and human intervention studies, which take place in the final phase of functional food design and are the basis for their claims of functionality. The Centre is open not only to Catalan companies, but also to all those that are interested in this type of approach.

Functionality aspects of browning reaction products

By Monica Anese, Dipartmento di Scienze degli Alimenti, University of Udine, Via Marangoni 97, 33100 Udine, Italy

e-mail: monica.anese@uniud.it

Browning reactions, which are some of the most important phenomena occurring in food during processing and storage, represent an interesting research area for the implications in food stability and technology, as well as in nutrition and health. These reactions can involve different

compounds and proceed through different chemical pathways. The major groups of reactions leading to browning are enzymatic phenol oxidation (i.e. enzymatic browning) and the so-called non-enzymatic browning. The latter is favoured by heat treatments and includes a wide number of reactions such as the Maillard reaction, caramelisation, chemical oxidation of phenols, and maderisation.

Melanoidans

A common characteristic of this wide number of reactions is the formation, as final products, of melanoidins which are macromolecular brown pigments containing nitrogen. Although a number of attempts have been made to define the structure of melanoidins using different analytical techniques, up to now, only a few melanoidins have been isolated from foods and characterised (1-3).

Current thinking is that melanoidins may be divided into two classes, namely the low molecular weight, consisting of up to four linked rings with molecular weight below 1000 Daltons, and the high-molecular melanoidins with molecular masses up to 150000 Daltons. In recent years, increasing attention has been focused on melanoidins formed during Maillard and caramelisation reactions for their unexpected functional and technological properties.

Radical scavenging and antioxidant properties

Several authors observed that melanoidins formed during the advanced stages of Maillard and caramelisation reactions exhibit strong *in vitro* antioxidant properties, mainly due to their ability to act as both radical and oxygen quenchers (4-5). In addition, due to their very low redox potential they can also act as reducing agents (6). Experimental data indicated that the radical scavenging properties of melanoidins are of the same magnitude as those of the commonly used food antioxidants BHA and BHT. These findings provide an important contribution to a better understanding of the complex chemical and physical events which take place in foods during heat treatments and have opened interesting and unexpected scenarios for the potential exploitation of melanoidins for technological and functional purposes. In fact, investigations carried out in different food matrices showed that Maillard melanoidins play a key role in extending the shelf-life of foods by slowing down the rate of undesirable oxidation reactions. For example, it has been demonstrated that the rates of lipid oxidation of the fat component of foods such as biscuits, tomato sauces, hazelnuts and coffee are significantly slowed down when melanoidins are added or formed during heating (7-9). In addition, if a vegetable-based food has to be thermally processed, the unavoidable loss of the naturally-present antioxidants (e.g. ascorbic acid, phenols, carotenoids, etc.) can be balanced by the formation of Maillard melanoidins in the advanced phases of the heating treatments (10). The antioxidant properties of Maillard melanoidins also seem to be the basis of their ability to inhibit oxidative enzymes such as polyphenoloxidase and peroxidise, and to exert antimicrobial effects against certain microorganisms (11-13). Many studies have found these properties to be positively correlated with the development of browning, i.e. the browner the colour the higher the antioxidant properties. However, simple positive correlation between colour and antioxidant properties can be achieved only in foods where the formation of Maillard antioxidants is the prevalent event during processing. On the contrary, antioxidant properties and

colour formation can follow opposite ways in multi-component and in formulated foods (e.g. tomato sauce made by tomato puree and oil; fruit and vegetable-based drinks), due to simultaneous development of a number of reactions, which interact with the Maillard reaction itself (such as lipid or natural antioxidant oxidations) (14). Studies with coffee (15) indicated that melanoidans exert a weak antiradical activity in watery fluids which was significantly lower than that of classical antioxidant compounds (tannic acid, ferrulic acid, caffeic acid, gallic acid and Trolox) in aqueous medium.

Health properties

Melanoidins are also believed to possess a range of health related properties most of them still unexplored. Most of these topics represent the overall objectives of the ongoing COST Action 927 "Thermally treated foods: possible health implication", which links together European scientists working on the different aspects of the non-enzymatic browning reaction. Outcomes from the COST Action include results from *in-vitro* tests which demonstrated that at least some of the dietary melanoidans are degraded by intestinal microorganisms, possibly influencing their growth rate (16). Follow-on animal studies have demonstrated that at least 30% (of the ingested weight) of low molecular weight compounds were absorbed. Structure-specific health promoting effects of newly identified Maillard reaction products have been described by means of their antioxidant and chemopreventive activity in cell culture investigations as well as in animal feeding studies and human trials (16). Harmful effects of dietary melanoidans have been investigated in the context of their ability to promote glycation reactions *in-vivo*. These are involved in the progression of several diseases including diabetes mellitus, cardiovascular complications, and Alzheimer's disease (16). The significance of melanoidans to health has also been reviewed by Somoza (17) in the context of their formation, their content in foods, typical daily intakes, their metabolism, potential health effects, anti-carcinogenic

action, chemopreventive action, and other aspects.

Conclusions

On the basis of the above considerations, the presence of Maillard melanoidins in foods means that we consume products with lower levels of oxidation which are also potentially safer from a microbiological point of view. With reference to the *in vivo* effects of Maillard melanoidins, data are still scarce and somewhat contradictory, mainly due to the fact that heating is responsible for the formation of Maillard melanoidins which have a range of different structures and chemical composition. By virtue of their antioxidant capacity, melanoidins are expected to exert a range of interesting functional properties *in vivo* (18-19). In particular, according to the results of some recent epidemiological studies, they could exert a role in the prevention and/or protection against degenerative and chronic diseases such as cancer and cardiovascular disease.

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Gluten-free research: some new ingredients in the mix!

By Eimear Gallagher, Ashtown Food Research Centre, Teagasc, Ashtown, Dublin 15, Ireland

e-mail: Eimear.Gallagher@teagasc.ie

Gluten-free bakery products can be regarded as 'double' functional foods. Firstly, they are 'inverse' functional foods in that a key constituent, i.e. gluten is omitted rather than being included. Secondly, they act as conventional functional foods as they are excellent carriers for healthy ingredients such as dietary fibre, prebiotics, available calcium, and other constituents. It is against this background that recent research on gluten-free bakery products is highlighted below.

Coeliac disease

Coeliac disease is a life-long intolerance to the gliadin fraction of wheat and the prolamins of rye (secalins), barley (hordeins) and possibly oats (avidins). The reaction to gluten ingestion by sufferers of coeliac disease is inflammation of the small intestine leading to the malabsorption of several important nutrients including iron, folic acid, calcium and fat-soluble vitamins. Symptoms associated with coeliac disease include diarrhoea or

constipation, anaemia, mouth ulcers, fatigue, neuropsychiatric symptoms (anxiety, depression) and osteoporosis. The disease is more common in Ireland than anywhere else in the world. It is particularly prevalent in the West of Ireland. The only effective treatment for coeliac disease is a strict adherence to a gluten-free diet throughout the patient's lifetime, which, in time, results in clinical and mucosal recovery.

Recent epidemiological studies show a significant increase in the incidence of coeliac disease and gluten intolerances, mainly due to the improved diagnostic procedures. The worldwide average of sufferers has been predicted to increase by a factor of ten over the next number of years, resulting in a growing market for gluten-free cereal-based products.

Market research

Market research has shown that many of the commercially available gluten-free products are of inferior quality. The replacement of gluten presents a major technological challenge, as it is the main structure-forming protein in wheat flour. It is responsible for the elastic characteristics of dough, and contributes to the appearance and crumb structure of many baked products. The protein fractions in gluten are glutenin and gliadin. The former is a rough, rubbery mass when fully hydrated, while gliadin produces a viscous, fluid mass on hydration. Gluten, therefore, exhibits cohesive, elastic and viscous properties that combine the extremes of the two components, and the gluten matrix, and therefore, is a major determinant of the important properties of dough (extensibility, resistance to stretch, mixing tolerance, gas holding ability), which encloses the starch granules and fibre fragments. Gluten removal, especially in bread formulations, results in major technical problems for bakers, yielding liquid batter rather than dough (Figure 1), and bread with a crumbling texture, undesirable colour and other quality defects.

Programme objectives

The objective of the ongoing research programme at Ashtown Food Research Centre on gluten-free bakery products is to examine how a diversity of ingredients can be used to manipulate the batter and baked characteristics of bread that is suitable for those with coeliac disease or wheat intolerance. Novel and functional ingredients were used to formulate gluten-free breads, and their effects on overall appearance, crumb, shelf-life and sensorial characteristics, when compared with their gluten-containing counterparts were measured.

Approaches taken

1. Dairy powder: The incorporation of dairy ingredients has long been established in the baking industry. Dairy proteins are highly functional ingredients and due to their versatility can be readily incorporated into many food products. They may be used in bread for both nutritional and functional benefits including flavour and texture enhancement, and storage improvement. Dairy products may be used in gluten free bread formulae to increase water absorption and, therefore, enhance the handling properties of the batter. Gluten free breads often have poor crust and crumb characteristics and the current study was conducted to help alleviate this problem.

A commercial wheat starch (Codex Alimentarius) gluten free flour was supplemented with seven dairy powders of protein content from 3% – 90% (0, 3, 6, 9% inclusion rates based on flour weight). It was found that powder addition reduced loaf volume by approx. 6%. Powder addition generally decreased the crumb L*/b* (white/yellow) ratio. Generally, the powders increased crumb hardness. Sensory analysis revealed a preference for breads containing skim milk replacer, sodium caseinate and milk protein isolate. Research with novel dairy proteins is continuing.

(i)

(ii)

Figure 1: An elastic, extensible wheat dough (i), and a gluten-free batter (ii)

2. Fish surimi and inulin: Surimi is minced colourless, odourless fish flesh, that has been washed to remove as much of the oil, blood, enzymes and sacroplasmic protein as possible, and is stabilised for frozen storage by cryoprotectants. The myofibrillar protein in the resulting products is high in actomysin, which is highly elastic and capable of forming a strong gel. Surimi-based gels containing salt have an elastic and cohesive texture, and this can be exploited in the application of surimi as a functional ingredient. Gluten-free bread doughs lack extensible and elastic properties. They are difficult to work with, due to their batter-like consistency, and moulding as per normal dough is virtually impossible. The structure forming-properties of surimi were studied as a viable alternative to gluten.

A gluten-free bread formulation based on rice and potato starches was supplemented with fish surimi (as a potential structure enhancer). Frozen

surimis from mackerel, blue whiting, red gurnard and pollock were evaluated. In general, the inclusion of surimi darkened crust colour, and softened the crust and crumb. Microstructure of the gluten-free dough containing blue whiting surimi showed similarities to that of wheat dough. Paired comparison taste panel tests for acceptability indicated that the bread with blue whiting surimi was preferred to the control.

The same control formulation above was supplemented with inulin at 4% and 8% of starch weight. Inulin is a non-digestible polysaccharide, which has a positive health effect on the host by stimulating the growth or activity of beneficial bacteria in the colon, i.e. a prebiotic effect. It may be incorporated into baked goods for both its nutritional (prebiotic/dietary fibre) and its technological (texture/rheology modifier) properties. At the 4% level, loaf volume was significantly increased. At both levels of inclusion, loaf appearance was darker probably due to the enzymes in the yeast hydrolyzing part of the inulin, resulting in the formation of fructose and thus causing a browning of the loaf crust. At the 8% level of inclusion, dietary fibre content of the loaves was 7.5%; this is in contrast to the gluten-free control loaf (1.4%) and an ordinary wheat bread loaf (3.7%) (Figure 2).

3. Formulation optimisation: Response Surface Methodology (RSM) is a statistical technique which has been successfully applied in recent years in the development and optimisation of cereal products.

An optimised gluten-free rice bread formulation was developed using RSM, where optimum levels of hydroxypropylmethylcellulose (HPMC; a hydrocolloid) and water were determined. Response surface methodology was used to optimise a gluten-free bread formulation based on rice flour, potato starch and skim milk powder. HPMC and water were the predictor variables. From the data obtained, optimal ingredient levels were determined (Figure 3).

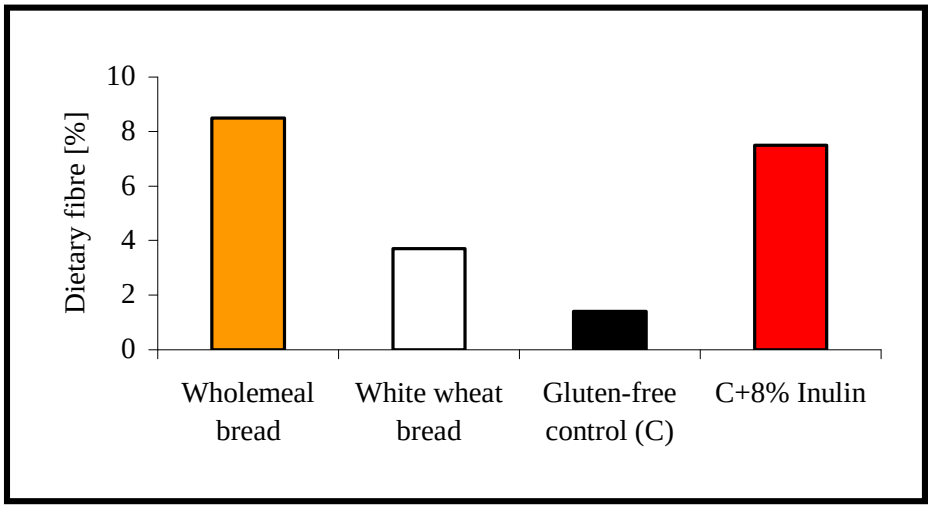


Figure 2: Dietary fibre contents of wholemeal and white wheat breads compared with gluten-free bread and gluten-free bread with added inulin.

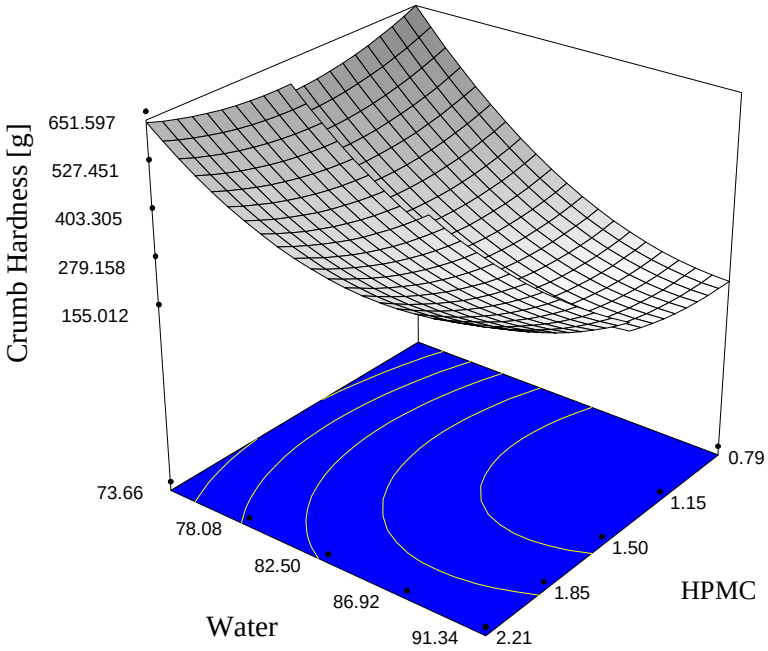


Figure 3. Effect of HPMC and water addition on crumb firmness of gluten-free breads made without wheat flour, rice flour, potato starch and skim milk powder.

4. Other protein sources: The effects of adding different protein powders to the optimised gluten-free bread formulation based on rice flour and potato starch were studied in relation to fundamental rheology and baking characteristics of the resulting gluten-free doughs and breads. The protein sources assessed were sodium caseinate, defatted soya flour and whole egg powder added individually. Their effects on dough rheological properties were investigated and the data were correlated with the baking characteristics of the breads. All results were compared to a control gluten-free bread formulation, which did not contain added protein. The addition of soya yielded firm doughs that displayed some elastic properties. The resulting breads had a low loaf volume and a compact crumb texture. Doughs containing egg powder had a relatively high complex viscosity (η^*) at peak gelatinisation temperatures, with the baked loaves having a yellow crumb appearance and firm crumb texture. The formulation containing sodium caseinate produced doughs with a high elastic response to changing frequencies, and loaves that had high volume. They were given the highest acceptability scores in taste panel tests.

Conclusions

A greater awareness and improved reliability of diagnostic procedures has recently highlighted the prevalence of coeliac disease. Lifelong adherence to a gluten-free diet remains the cornerstone treatment for the disease. However, gluten is a major component of wheat and rye flours, and its replacement in bakery products remains a significant technological challenge. The use of starches, gums and hydrocolloids represent the most widespread approach used to mimic gluten in the manufacture of gluten-free bakery products, due to their structure-building and water binding properties. Novel approaches including the application of dietary fibres, prebiotics and alternative protein sources combined with response surface methodology are also emerging. However, in view of the

increasing number of coeliac/gluten intolerant sufferers (due to improved diagnostic procedures), there is a major need for more research and development in the area of gluten-free cereal-based products.

More information

http://www.teagasc.ie/research/reports/foodprocessing/4881/eopr4881.htm

Grains were born to be functional - the HEALTHGRAIN project

By Jan Willem van der Kamp, TNO Quality of Life, Zeist, The Netherlands

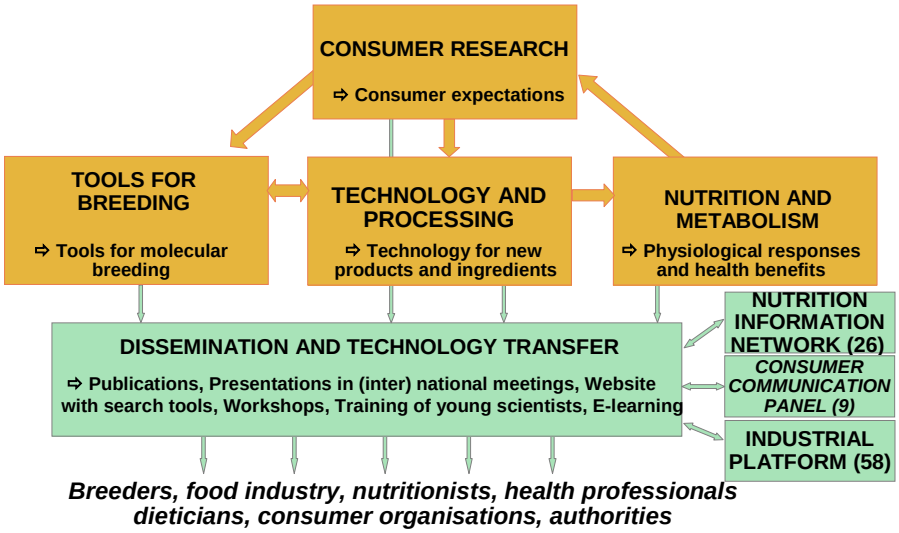
e-mail: jan-willem.vanderkamp@tno.nl

Introduction

Cereal grain based products with health benefits represent a growing part of the health related food market. The adoption of health claims (USA - 1999, UK – 2002 and Sweden – 2003) linking whole grain based products with a reduction of risk of coronary heart disease, significantly supported the major market growth in recent years. In addition, whole grain products are associated with a range of other health benefits, including a reduced risk of type-2 diabetes, obesity, and some types of cancer. In fact, the recent whole grain trend is a reversal of the main trend in the past century – towards highly refined products, without the outer part of grains. These outer parts are rich in fibre and a wide range of phytochemicals. Whereas market growth of whole grain products is expected to continue in the coming years, research in Europe is focussing on exploring options for a wider range of healthy cereal grain based

products, based on a deeper understanding of the mechanisms of whole grain health benefits.

HEALTHGRAIN Project Structure



The € 16 million HEALTHGRAIN Integrated Project (2005 – 2010) of the 6th EU Framework Programme, with 43 research groups from universities, institutes and leading cereal industries played a key role. HEALTHGRAIN aimed to improve the well-being and reduce the risk of metabolic syndrome related diseases in Europe by increasing the intake of protective compounds in whole grains or their fractions. The target bioactive compounds are vitamins (folate, tocols, choline etc.), phytochemicals (lignans, sterols, alkylresorcinols, phenolic acids) and indigestible carbohydrates.

HEALTHGRAIN research – short overview

The project was coordinated by Prof. Kaisa Poutanen (VTT and Kuopio University, Finland). HEALTHGRAIN's research included 4 Modules - on Consumer research, Breeding, Technology and Nutrition.

The Consumer research module, led by Prof. Richard Shepherd (University of Surrey, UK)

- Studied expectations of consumers for cereal-based products that have been modified to contain more health promoting components,
- Compared how appealing different kind of health promoting aspects of cereal-based foods are among European consumers, and
- Studies how they fit with the existing health image of various grain foods.

The first study, on consumer expectations in Finland, Germany, Italy and UK, showed whole grain foods are generally considered as beneficial. Health benefits are generally related to dietary fibre; in the UK also a link with heart health is observed, probably due to major advertising campaigns on whole grain products and heart health. A second study explored consumer attitudes towards a wide range of statements relating cereal grain products to glycaemic response and diabetes.

The Plant breeding and biotechnology module, led by Prof. Peter Shewry, (Rothamsted Research, UK) focused on identification and generation of new sources of nutritionally enhanced grain and provided a "biotechnology toolkit" for plant breeding programmes. The development of cultivars with increased concentrations of nutrients is essential for the delivery of benefits to consumers, particularly in white flour products which currently contain low levels of such components. It is, therefore, necessary to determine the distribution of components within the grain as well as the total amounts present in the whole grain, and in particular to focus on the starchy endosperm tissue which is isolated as white flour on milling.

150 wheat varieties and 50 other cereals (including 17 rye varieties) of diverse origins and ancestry have been grown on various sites throughout Europe and analysed for variations in phytochemicals (tocols, sterols, folates, phenolic acids, alkylresorcinols) and dietary fibre components (total and water soluble arabinoxylans, beta-glucans and total dietary fibre). The variation in most components in bread wheat was two to three-

fold but was wider in some cases, approaching 10-fold in free phenolic acids. The variation is determined by the genotype but also influenced by the environment. High levels of phytochemicals and dietary fibre are found both in ancient varieties and in varieties with good yield and processing properties.

The Food processing module, led by Prof. J. Delcour (Leuven University, Belgium)

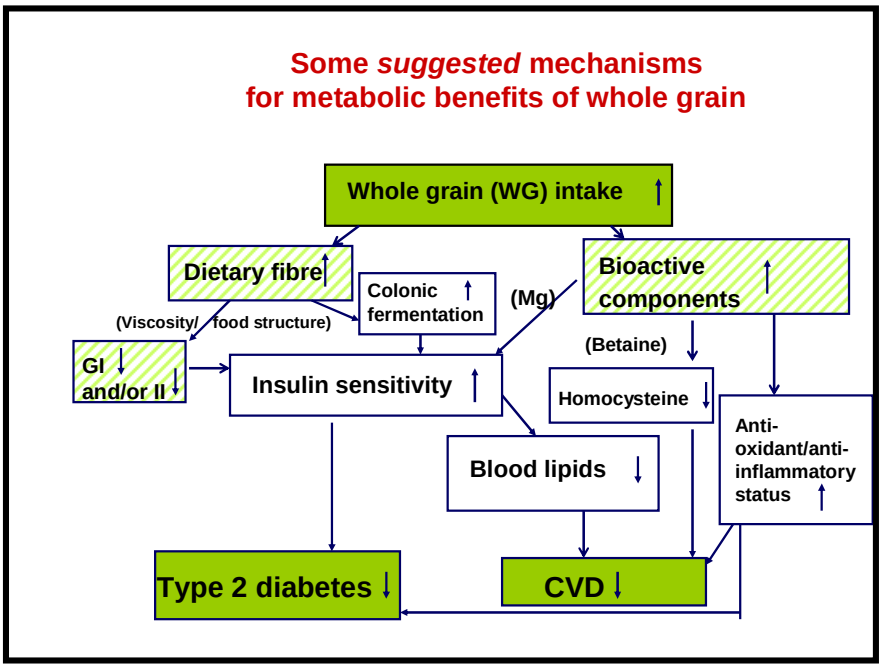
- Developed new food ingredients of high nutritional impact by isolation and/or processing of new cereal fractions using economically viable technologies,
- Developed cereal foods of high nutritional impact (including foods for individuals sensitive to wheat gluten) based on economically viable technologies,
- Studied process-induced changes of bioactive compounds in European grains,
- Evaluated and demonstrated the feasibility of the developed technologies in terms of industrial scale processing.

Specific emphasis has been on producing flour containing the majority of the grain bioactive components, but with enhanced processability in terms of sensory quality. Cryogenic milling has been developed for separation of the grain in new types of fractions, including fractions rich in the aleurone layer of grain kernels – an outer layer rich in fibre and phytochemicals. Development of enzyme technology in general and xylanase technology in particular, has allowed modification of biopolymer functionality; tailoring arabinoxylan modification is aimed at combining processability and beneficial prebiotic effects. Yeast fermentation improved the processability of both bran and wholegrain wheat flour in bread baking, and increased the levels of folate and soluble arabinoxylan. *Lactobacillus plantarum* was identified as a useful starter culture in baking of gluten-free breads, where enzyme technologies were also applied. This

work complemented studies aimed at a better understanding of the interactions during bread making of wheat gluten and whole grain components.

The Nutrition and metabolism module, led by Prof. Inger Björck (Lund University, Sweden) identified mechanisms responsible for the health benefits of whole grain products (e.g. foods rich in whole grain cereals or specific cereal fractions/components) on risk factors for CVD, type 2 diabetes and over-weight, and on utilising these mechanisms in the tailoring of new cereal products with magnified benefits.

In vitro antioxidant activity was shown to be high in aleurone and bran fractions, which also consistently increased plasma levels of betaine.



Intervention studies were conducted with healthy and 'at risk' subjects for testing the following hypotheses:

- Aleurone-rich foods impact favourably on metabolic risk factors
- Metabolic merits of whole grain diet are magnified by whole grain foods which are also low in glycaemic index (GI)

- Whole grain influences body weight by stimulating satiety via bulking, and by reducing the digestibility/absorption of the energy nutrients
- A diet with multiple beneficial characteristics of whole grains favourably influences glucose and insulin metabolism in subjects with metabolic syndrome
- Some *suggested* mechanisms for metabolic benefits of whole grain

Dissemination and technology transfer – networking and paving the way for innovations

The Dissemination and technology transfer module, led by Dr. Jan Willem van der Kamp (TNO, Netherlands) focused, in addition to communication of results, on the creation of networks of stakeholders relevant for the development and public acceptance of healthy grain based products. The Nutrition Information Network (NIN) and the Consumer Communication Panel (CCP) were set up to establish contacts with the leading European nutritionists and experts in communication to consumers. HEALTHGRAIN was unique among EU projects with these networks and especially with its **Industrial Platform** (IP). IP membership –with fees of €25.000 for large companies and €2.500 for SMEs – included 58 companies in 13 countries 25 of them SMEs. They include major flour millers and ingredient suppliers, food multinationals, breeders and suppliers of equipment and analytical tools. Members of IP, NIN and CCP had access to parts of the annual project meetings and to the protected part of the website, with a wealth of publicly available information. In annual Workshops for IP members, new HEALTHGRAIN results were discussed in relation to related research, consumer trends and – last but not least - the impact of Regulation (EC) 1924/2006 on Nutrition and Health Claims made on foods.

Workshops held for Industrial Platform, NIN and CCP members included:

- *Health benefits of whole grain components and products - new insights and support of claims*,

- *Health and nutritional claims in relation to the HEALTHGRAIN product pipeline - Consumer perceptions*, Paris 3-4 Nov. 2008 (preceding HI Exhibition, 4-6 Nov.)

Acknowledgements

This publication was financially supported by the EU 6thFramework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008). It reflects the authors' views and the Community is not liable for any use that may be made of the information contained in this publication.

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3. www.healthgrain.org

Herbal teas: their potential as health promoting beverages and bioactive functional foods

By Gerhard Kroyer, Department of Natural Products and Food Chemistry, Institute of Chemical Engineering, University of Technology, Vienna, Austria

e-mail: gkroyer@mail.zserv.tuwien.ac.at

In recent times, there is a growing interest in nutrition and preventive health care in the development and evaluation of natural bioactive and antioxidant active products from plant materials. It is well known that polyphenol compounds are responsible for the potential antioxidant activity and radical scavenging capacity of plant foods. Consumption of a

diet rich in polyphenol substances has been linked with a reduced risk for cardiovascular diseases and certain types of cancer. Dietary natural antioxidants strengthen the endogenous antioxidant system by reducing oxidative stress and the risk of toxic diseases. Radical scavenging antioxidants are particularly important in antioxidant defense to protect cells from the injurious effects of free radicals. Free radicals are very reactive chemical species, eventually evoking uncontrolled reactions, resulting in oxidative damage of important biological macromolecules. Polyunsaturated fatty acids which are major constituents of cell membranes are particularly susceptible to free-radical-mediated oxidation because of their conjugated bond structure. Consequently, the process of lipid peroxidation can lead to disturbances in membrane structure and function. Furthermore, and viewed in a global sense, polyphenol compounds as free radical scavengers can act as anti-inflammatory, anti-bacterial, anti-carcinogenic, anti-allergic and immune-stimulating agents.

Herbal teas

Common traditionally consumed herbal teas of different origins were investigated for their content of total polyphenols and evaluated for their potential bio-active antioxidant properties, especially in reference to their comprehensive nutritional-physiological and health promoting effects:

Rooibos tea - traditionally grown and consumed in South Africa

Maté tea – originated from South America

Peppermint tea - commonly consumed in Europe and North Africa

Mallow tea and **Chamomile tea** - widely consumed in Europe

Rooibos tea

Maté tea

Peppermint tea

Mallow tea

Chamomile tea

Preparation of herbal teas and herbal tea extracts

Herbal teas were prepared by brewing with hot boiling water according to practical usage. After evaporation of the solvent, the resulting aqueous herbal tea extracts were subjected to analysis of their content of total polyphenols (*Folin-Ciocalteu)* and antioxidant and radical scavenging capacity (*DPPH radical scavenging method*).

Content of total polyphenols

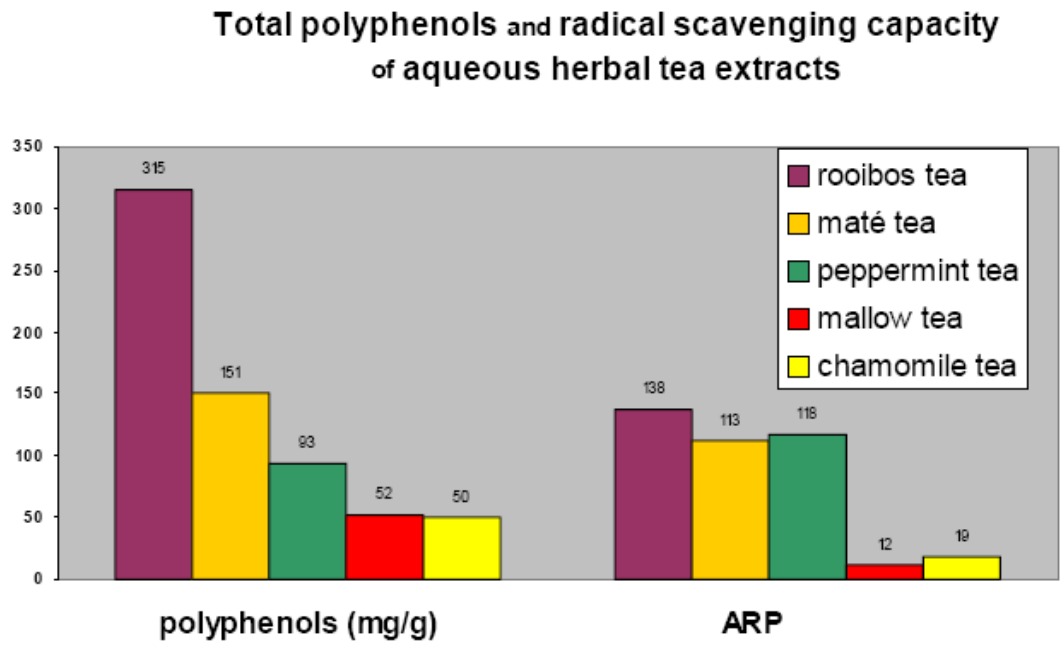
All the herbal teas showed considerable amounts of polyphenol substances in their aqueous extracts. The highest content was found in Rooibos tea, followed by Maté tea, Peppermint tea, Mallow tea and Chamomile tea.

Antioxidant and radical scavenging capacity

Correspondingly, the highest radical scavenging capacity (expressed as anti-radical power ARP) was observed in the aqueous extract of Rooibos tea. Remarkable and comparative radical scavenging properties were found in the aqueous extracts of Peppermint tea and Maté tea, whilst the extracts of Mallow tea and Chamomile tea showed only low but still detectable antioxidant activity. There appears to be a general correlation between the antioxidant properties and the total polyphenol content. Slight differences in the range of antioxidant activities might be attributed to variations in the amounts of different polyphenol substances and/or the additional presence of other antioxidant active components.

Conclusion

Consumption of herbal teas is helpful in maintaining and promoting health, particularly in consideration of their beneficial impact to public health, and especially in respect of cardiovascular disease prevention. Furthermore, herbal tea extracts could be regarded as effective natural antioxidant additives for food products and as functional dietary food supplements due to their significant content of total polyphenols. These are bioactive substances and have significant radical scavenging capacity.



Modifying the fatty acid profile of foods – lessons from the *Lipgene* project so far…..

By Rebecca Foster & Joanne Lunn, Nutrition Scientists, British Nutrition Foundation, London, UK
e-mail: r.foster@nutrition.org.uk

As the proportion of the European population that is classified as obese increases, so too does their risk of suffering from the metabolic syndrome and associated complications. Closely allied with this are the escalating health care costs to the EU.

Metabolic syndrome

This is characterised by a number of strongly inter-related risk factors for cardiovascular disease, including obesity, dyslipidemia, insulin resistance and hypertension (see Nugent, 2004). Initiatives to reduce the risk of adverse health conditions associated with the metabolic syndrome, such

as dyslipidemia (an unhealthy balance of the types of fat in the diet), could consequently reduce the costs of ill-health. Modifying the fatty acid profile of commonly consumed foods is one such initiative – the feasibility and implications were investigated as part of the multi-disciplinary *Lipgene* project. However, it is difficult to increase the proportion of these health promoting fatty acids in foods. Furthermore, conventional methods of modification rely on the use of fish oils, yet there is evidence of dwindling fish stocks. Importantly these barriers are being considered as part of the *Lipgene* project, along with the financial implications. Potential solutions to the problem involve the use of various forms of agro-food technologies, including transferring the relevant traits of microalgae to oil seed plants using genetic modification technology. Clearly some consumers may have ethical concerns about such techniques and, therefore, consumer research is also underway in association with the *Lipgene* project.

Consumption of PUFAs

Since the 1960s, doctors and healthcare professionals have recommended the consumption of oils rich in polyunsaturated fatty acids (PUFAs) in place of saturated fatty acids (SFAs) to decrease the SFA content of the average diet, as it is well recognised that even small changes in blood lipid profiles can have important changes for the risk of dyslipidemia, and overall heart health. Certain long chain *n*-3 PUFAs, namely eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are also well recognised as important in protecting against fatal heart disease, although not simply by bringing about favourable changes in blood lipid profile. These long chain *n*-3 PUFAs have also been associated with (a) reduced blood pressure, (b) improved inflammatory response and endothelial function, and (c) protection against fatal arrhythmia along with many other effects, both known and as yet undefined.

To date, successful initiatives to improve the profile of dietary fatty acid intake have used animal derived products. For example, EPA and DHA enriched eggs which are currently on the market in a number of EU countries. Such eggs can provide 54mg of EPA and DHA per day, compared to normal eggs which provide only 8mg. Research in association with the *Lipgene* project by Givens and Gibbs (2006) indicates that for the UK, it is possible that with consumption of these specialist products, coupled with an increase in long chain *n*-3 PUFAs from enriched poultry meat and dairy products (consumed in line with current intakes), the intakes of long chain *n*-3 PUFA from non-fish sources could increase to approximately 200mg per day. However, such increases can only be realised if efficient methods of increasing the long chain PUFA composition of regularly consumed foods such as meat are identified.

With the increasing popularity of poultry, it is interesting to note that in mono-gastric animals, limited transformation of dietary fatty acids occurs during digestion and absorption. Therefore, supplementation of animal feed with fish oils is an effective method of increasing the concentration of these nutritionally important long chain *n*-3 PUFAs in the meat. Research as part of the *Lipgene* project has found that the long chain *n*-3 PUFA concentration of poultry meat following enrichment of EPA varies with the breed of bird (Givens & Gibbs 2006). However, a number of challenges have been identified when considering enriching foods with fish oil. The first is the susceptibility of *n*-3 PUFA oils to oxidative deterioration as it can cause the foods to have a metallic, fishy flavour and a short shelf life. Secondly, perhaps most importantly, there are concerns about the declining fish stocks.

Fish oils and other sources of long chain PUFAs

It is now well recognised that fish oil is not a sustainable resource. Natural fish stocks are in decline, and aquaculture of marine fish requires a dietary supply of fish oil as they have insufficient exposure to microalgae

(from where the wild fish obtain long chain *n*-3s). It is currently estimated that aquaculture consumes 97% of the current production of fish oil. Therefore, we need an alternative, sustainable source of nutritionally significant long chain *n*-3 PUFAs for both human nutrition and for aquaculture. Marine algae, notably microalgae, are the primary dietary source of EPA and DHA for oily fish in the wild, and are commercially exploited by growing in culture. In the search for a sustainable and economically viable source of long chain *n*-3 PUFAs, researchers are looking at the feasibility of genetically engineering oil seed crops to act as a production system for the synthesis of long chain *n*-3 PUFAs, which would accumulate in the storage lipids of their seeds. In turn, these seeds could be used to produce vegetable oils rich in long chain PUFA. Most oilseeds accumulate linoleic acid, but not the long chain PUFAs of carbon chain length of 20 or more. To convert the endogenous plant fatty acids into very long chain PUFAs requires the action of multiple enzymes, in particular elongase and desaturase, which are not present in oilseeds. In recent years there has been significant progress in identifying and isolating the necessary genes encoding long chain *n*-3 PUFA biosynthesis enzymes from fungi and algae. These genes then need to be inserted into a suitable oilseed crop to generate the long chain *n*-3 PUFAs. This action requires transgenic pathway engineering, through which there are already signs that plants can be stimulated to accumulate modest levels of long chain *n*-3 PUFAs (currently around 3% EPA; Qi *et al*. 2004). However, understanding how to optimise the accumulation of long chain *n*-3 PUFAs in the transgenic plants is a requirement, and this is being considered as part of the *Lipgene* project (see Napier & Sayanova 2005). To date, the research has used flax-linseed, with little success. Oil seed rape is being used to further the research, and to-date transgenic plants have been engineered to produce long chain *n*-3 PUFAs and arachidonic acid to commercial levels.

Economics module

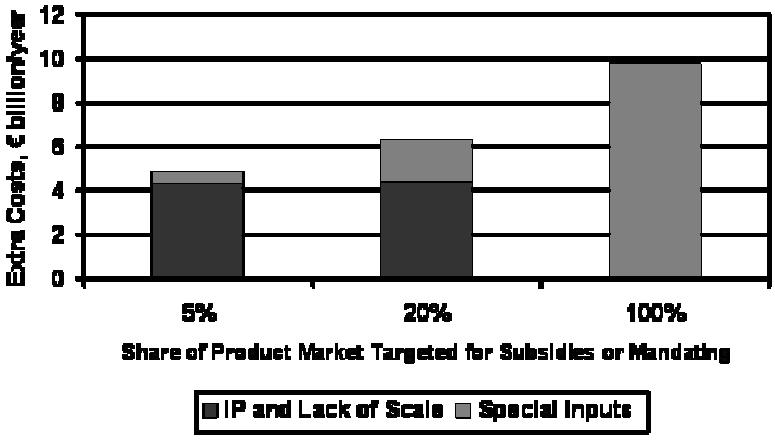
If specialist products, such as a long chain *n*-3 PUFA rich vegetable oil (or products containing it), are sold at a premium, they are only a feasible option for individuals who can afford the higher price tag. For the potential benefits of specialist foods to be recognised, schemes that can ensure these foods reach individuals who will benefit most need to be developed. Two possible schemes to tackle this problem have been considered as part of the economics module of the *Lipgene* project:

The first scenario assumes there is potential to subsidise the production on inputs such as plant sterols, linseed and fish oil for all EU soft spreads, poultry and beef outputs, bringing retail prices of modified foods just below those of conventional foods. Fry and Finley (2005) estimated that a subsidy of €10 billion per year would be required to modify all EU soft spreads, poultry and beef, to cover the costs of special inputs (*e.g*. ingredients). This is an extreme example, which assumes that everyone receives 'healthier' animal products, regardless of whether they are of direct benefit to them or not. It also assumes that big increases in the use and provision of key inputs are possible without increasing their prices. However, this scenario has the benefit of avoiding all identity preservation costs and it ensures the attainment of economies of scale.

The second option is to target subsidies, via vouchers for example, to ensure that those who would benefit most from specialised products have the chance to do so. This is particularly important, as those on a lower income (and perhaps less likely to be able to afford the higher price tag associated with specialised products) are more likely to be obese and at risk of coronary heart disease (CHD). However, this approach may fail to reach many of the beneficiaries (as some people may be unaware of such a scheme or the potential health benefits of the products), and does entail additional administrative costs and incurs penalties from lack of scale. In order to determine the potential financial impact of targeting subsidies,

the costs of targeting 5% and 20% of the EU population were calculated by Fry and Finley (2005). The overall financial impact of lack of scale plus identity preservation systems are similar for both the 5% and 20% level of subsidisation at roughly €4 billion/year each. According to Fry and Finley (2005), extra costs of special inputs bring the net costs to around €5 billion/year for the 5% level of subsidisation and €6 billion/year for the 20% level. The costs of targeted subsidisation can be compared favourably with subsidising 100% of the population, which is estimated to be €10 billion/year (see Figure 1). However, it is also important to consider the cost-efficiency of such a scheme.

Figure 1. Costs of targeting subsidies on 5%, 20% and 100% of the EU population.



Source: Fry & Finley, 2005

Consumer choice

Clearly there are a number of opportunities for producing foods with healthier traits, with the potential for health care savings and improved consumer choice. However, there are currently a number of barriers also, not least the science and technology challenges, but also the potential consumer concerns. Research into the views of consumers around the metabolic syndrome and its perceived health risks, has been undertaken on behalf of the *Lipgene* project to provide an important insight into how people can be encouraged to take responsibility for their health and diet. Food choice is influenced by a number of issues including the potential

health consequences of the diet. Ethical issues about where food has come from are also important to some consumers and, therefore, investigating whether foods produced by new technologies will be acceptable to consumers will be an important outcome of the *Lipgene* project.

Extensive surveying of opinion in six European countries has established the level of awareness and acceptance of the metabolic syndrome and the agro-food technologies that may provide an option for tackling its rising prevalence. Results suggest that European consumers are aware of diet-related diseases and associated risks. They want health benefits from their foods and would accept genetic testing to know their disease risk. They would like diets tailored to their needs and would accept GM foods if they provide health benefits. However, awareness of metabolic syndrome is very low, which immediately identifies an area where public health activities need to be focussed. Unsurprisingly, consumers are ill informed about GM foods and the concept of functional food is not well recognised.

Conclusions

Clearly there are a number of opportunities for producing foods with healthier traits and with potential for health care savings and improved consumer choice. However, the science and technology challenges, but also the potential consumer concerns are possible barriers. These issues are being explored by the various aspects of the *Lipgene* project. See findings at (http://www.nutrition.org.uk/lipgene).

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Prebiotics – Providers of the FeelGood Factor!

By Jan van Loo, ORAFTI Group, Belgium
e-mail: jan.van.loo@orafti.com

"Wellbeing" and "wellness" have become part of our everyday language, with diet and healthy living high on many people's agenda. Prebiotics, as food additives, are now being explored by major manufacturers worldwide to respond to this growing trend. Prebiotics allow manufacturers to make a number of health claims as well as enhancing the general 'FeelGood Factor'.

What are prebiotics?

The most powerful and researched prebiotics are inulin and oligofructose. These are natural food ingredients extracted from the chicory root. Inulin occurs naturally in thousands of plants and vegetables including artichokes, leeks and onions but the chicory root is a particularly good source and one, which is the most researched by scientists for its nutritional benefits.

A healthy digestive system has everything to do with a balanced and nutritious diet and fibres play a key role in this. Inulin is a soluble fibre, which has the same affect as fibres from fruits, vegetables, wholesome bread and cereals.

Communication – the right way

The offering of prebiotics has also grown over the years with numerous claims and stories. For this very reason ORAFTI Active Food Ingredients has simplified and refocused its communication to give guidance through the ever growing functional food sector. ORAFTI has changed its FeelGood ingredients, Raftiline® and Raftilose® to Beneo™, bringing the food industry and consumer communication closer together, and allowing one synonymous message to be conveyed and understood by all.

Validating the prebiotic effect

Good intestinal health is achieved when the composition and activity of our microflora are in balance. Unlike its probiotic counterpart, prebiotics are not live bacteria, but non-digestible fibres that pass through the stomach and small intestine intact. With regular intake of inulin and oligofructose at levels of 5 to 8 grams each day[i], the bifidobacteria are stimulated and increase in number by as much as 5-10 times. The level of harmful organisms in the digestive tract, such as clostridia, is also reduced. By fermenting - rather than digesting - in the colon, they act as prebiotics, helping to maintain a healthier balance of the intestinal microflora, promote bowel regularity and improve calcium absorption. And because our digestive systems then work better, we feel better.

The science

ORAFTI Active Food Ingredients, worldwide market leader in the production and commercialisation of Beneo™ inulin and oligofructose is also the driving force behind the scientific research. In collaboration with 75 universtities and research centres worldwide the health benefits of Beneo™ inulin and oligofructose are documented with more then 125 studies published in peer reviewed magazines.

Several studies with ORAFTI's patented enriched inulin has proven that the absorption of calcium can be enhanced by 20%. A resent study by Prof. Abrams from Baylor College of Medicine and the Texas Children's

Hospital showed that even the bone mineral content can be increased by 15% after 1 year of supplementation and the change in bone mineral density by more than 45%, an effect that has never been shown before with inulin. This opens the door to a new type of bone health claims!

Consumer insight for manufacturers

ORAFTI provides food manufacturers not only with scientific support but also consumer understanding into how these benefits can be made relevant to consumers.

Results from market research ORAFTI conducted in 13 countries, are communicated with its customers delivering the same conclusion - consumers everywhere are looking for the 'FeelGood Factor'. A Participant in the market research said that they would like to be able to buy inulin and oligofrustose in dairy products, bread, breakfast cereals, pasta, spreads foods - easily available products that the family consume as part of their daily diet; foods which taste good while also providing positive health benefits. But the communication needs to be clear and straight-forward, consumers do not want to be confronted with long scientific names and tales of disease and disorder.

ORAFTI's vast consumer insight has lead to the creation of its very own consumer communications platform called the Beneo™ programme. The Beneo label, when present on food packaging, indicates that prebiotics are present within the food product at a dose that is beneficial to the end consumer. The programme was launched worldwide in November 2005 and is already helping to market over 150 products across the globe.

Functional foods – the opportunities

Prebiotics are increasingly more common in staple foods that are eaten daily e.g. dairy, bread, fruit drinks, cereals and milk formula. This allows the prebiotic affect to take place through the consumption of a regular

dose. More than 1750 consumer products worldwide include already inulin and oligofructose. Some recent examples include:

Dairy

The dairy market has seen a particular increase in using prebiotics as additives to enhance health claims and create innovative new products. For example Dairy giant Müller has reformulated its Vitality range to incorporate prebiotics to enhance its digestive health claims and provide yoghurts and dairy drinks that promote the feel good factor.

Breakfast products

Again leading manufacturers within this market sector have incorporated prebiotics into products to enhance health claims. The trialed Kellogg's Muddles were so successful with its 'Keep Tummies Healthy' claim that the product name has now been altered to 'Rice Krispies Multi-Grain' which is an extension of one of its flagship sellers. Similarly Quaker Oats, Rivita and Alpen have added inulin to snack bars to help consumers optimise their digestive health.

Prebiotics and wellbeing – the future

So what does the future hold for foods and beverages that promote digestive health? Expect ingredients such as prebiotics to continue to figure strongly as consumer awareness of the importance of good digestive health continues to grow. Ask people how they feel when their stomach is upset or when they have eaten badly - they can be very graphic in their description of how they are feeling. And how about when they are back to normal and their digestive system is working better? Now that's the feeling of wellbeing! More information is available on www.orafti.com

"Probiotics: Nature's own functional agents"

By Yolanda Sanz, Head of Microbial Ecophysiology Group. Institute of Agrochemistry and Food Technology (IATA). Spanish National Research Council (CSIC)
e-mail: yolsanz@iata.csic.es

Gut microbes living in partnership with us

Our gut is populated by an array of bacteria that by far outnumber eukaryotic cells in the entire human body. Since birth, this consortium of bacteria co-evolves in partnership with their host, providing reciprocal benefits to each other and, thereby, improving gut physiology, metabolism and immunity. Environmental factors as well as disease may cause imbalances in the gut microbiota composition, and thus its modulation by dietary strategies (pro- and prebiotics) has been proposed to stay healthy. In this way, nature gives birth to the probiotic concept although the origin of Probiotic Science dates to the 20th century when Metchnickoff associated regular fermented milk consumption with longevity. Lactic-acid bacteria and bifidobacteria have a long-record of safe use in fermented foods and are also natural inhabitants of the human gut. Strains of these bacterial groups are thus considered naturally functional agents and, consequently, have increasingly been incorporated into the functional food market. Nowadays, the use of these bacteria to improve human health has moved from concept to actual demonstration of specific benefits by particular bacterial strains. Furthermore, a larger variety of commensal bacteria is being included in probiotic products as we expand our knowledge of gut bacterial diversity and functionality within the human body.

What are probiotics?

Probiotics are currently defined as live microorganisms that when administrated in adequate amounts confer health benefits to the host [FAO/WHO, 2002]. Some of these friendly microbes have already become part of our daily diet and are thought to help recover healthier lifestyles, which have been disrupted worldwide. The currently accepted probiotic concept is also expected to develop on gaining a better understanding of the mechanisms and molecules behind the beneficial effects of these microorganisms. These advances will provide new applications for probiotics and their derived-products, which could extend market opportunities, initially born in the food sector, into the pharmaceutical market. Joint ventures between both sectors are already flourishing around microbial bioactive-compound exploitation.

Health claims of probiotic effects

The new European regulation on health and nutritional claims of functional foods (EC Nº 1924/2006) includes those containing probiotic cultures. Guidelines for probiotic evaluation published by a joint expert committee of the World Health Organization and the Food and Agricultural Organization of the United Nations (2002) are recognized as an additional document essential for critical review of this category of functional foods. It has been demonstrated that technological and beneficial properties of probiotic microorganisms are strain-specific. Thus, probiotic products should be well-defined, regarding type of microorganism and carrier-dose. This involves the identification of probiotics at strain level and evaluation of their viability at the end of the product's shelf-life. In this context, the International Probiotics Association (IPA), in consensus with industry, has recently set criteria for a mooted labelling scheme that will allow probiotic products to bear a quality seal. The probiotic efficacy should also be scientifically sustained by well-conducted human clinical trials for a specific health target and dose. So far, health messages of probiotic products have mainly focused on general well-being and intestinal

balance, but now such claims are being officially evaluated before being accepted on the EU list of permitted claims. Probiotic health claims submitted to the EU Commission for approval include, among others, improvement of natural defences, immune function, digestive health, intestinal transit, gut integrity, and balanced microbiota during antibiotic treatment. More-specific health claims are also expected to appear on the market as a result of this new regulation and progress in line with improved understanding of gut microbiota functions. To be qualified for the EU list, health claims must also be well understood by the consumer. Science has progressed quickly in providing consumers with answers about probiotic health benefits. Despite this, most mass-market users still lack a clear understanding of the specific nature of gastrointestinal functioning and the concept of probiotic action. Advanced strategies in public education and communication programmes concerning probiotic claims are also emerging as part of the commitment of stakeholders involved in functional food development.

Probiotic-containing foods

Probiotics incorporated in fermented dairy products have been particularly successful on the European functional-food market, because milk is suitable for preserving probiotic viability and such products are well accepted by European consumers. The dairy product category has also dominated new product developments in recent years. The diversity of probiotic food applications is, however, extending to other food categories, including fruit juices, soups, chocolate and soy- and cereal-based products. In fact, Frost & Sullivan predicted rapid expansion in the human food and beverage probiotics market in 2006, which could potentially grow from $61.7 million to $163.5 million in 2013 with particular emphasis on the non-dairy food products segment. In such context, probiotic juices are viewed as a market opportunity that could take second place to dairy products shortly.

Challenges in the probiotic market

The major challenge of the probiotic market is ensuring survival of probiotic strains under harsh technological and gastrointestinal conditions. Doing this will enable probiotic applications to be extended to non-dairy products, as well as put functionally attractive but less robust strains on the market. In recent years, novel oral delivery systems based on encapsulation and packaging strategies are enabling the inclusion of probiotics in new food matrixes. *The* use of coating-bacterial techniques has facilitated the incorporation of probiotics in ice-cream and cereal production. Likewise it has improved the ability of probiotic bacteria to survive contact with gastric juices and reach the intestine in a viable form inside fermented milks. Incorporation of probiotics into packaging materials is also being explored as a tool to keep probiotic stability during shelf-life. For example, bacteria have been incorporated into a juice product with prolonged shelf-life by protecting them in a "blister" inside the bottle cap, which only releases the bacteria on opening.

Opportunities in-line with understanding gut microbe functions

Traditionally, the probiotic market has relied on the recognised ability of some microbial strains to influence gastrointestinal health and functions. Nowadays gut microbiota are thought to have the potential to boost health inside as well as outside the gastro-intestinal tract. In fact, probiotics continue to inspire some of the best innovations in the functional food sector. Probiotics are currently at the forefront of research into ingredients that can provide benefits to subjects with particular needs, as well as to combat lifestyle-related disorders and degenerative diseases. Among these are stress, food intolerance, type 2 diabetes, obesity, ageing, kidney failure, and oral and skin health. In nutrition, some of the most striking studies are those showing that ***genetically identical animals have metabolically different characteristics based on their gut microbiota, opening the door to use pro- and prebiotics in metabolic control.*** *In recent years, p*robiotic microorganisms have also

been marketed in sports drinks to relieve the stress symptoms associated with long physical exercise. Another recent probiotic application is the incorporation of beneficial bacteria into dental health products, such as sugar-free chewing gum, to combat harmful mouth microbes. Undoubtedly, these are smart examples of probiotic applications and opportunities; nevertheless, these only represent a small part of the full potential of the microbial world that humans harbour inside.

Development of functional foods for dementia patients

By Marco Bachmann and Katja Ramseyer, Zurich University of Applied Sciences Wädenswil (ZHAW), School of Life Sciences and Facility Management, Switzerland
e-mail: baco@zhaw.ch

Summary
Dementia patients frequently suffer from nutrition deficiency, which can be partly compensated for with specially adapted functional food. One hundred and forty four retirement and nursing homes in Switzerland participated in a survey to determine nutritional tendencies. The results show that 85% of the homes are trying to improve the food intake of the residents by changes in catering. Furthermore, 61% of the homes are interested in introducing functional food products, and only 10% completely reject this idea on the grounds of the conservative attitudes of the residents towards change.
Two sweet, and two savoury functional food products were developed which take into account the most important nutritional recommendations in respect of common health problems (diabetes mellitus, obstipation, hypertonia, hyperlipidaemia, gout). The sweet functional foods were offered to the residents as snacks in different places and the dementia patients showed their approval of these products. The savoury products

were presented as a supplement to main meals on a separate plate. However, serving functional food together with the usual meal was found to be less favourable because the patients frequently reacted to the new products in a confused way.

In order to ensure the acceptance of functional food products and thus successfully introduce functional food, both residents and their relatives must firstly be informed of the reasons for, and advantages of, the innovation.

Introduction

The nutritional behaviour and nutritional status of elderly people are often greatly affected by physiological (sense organs, chewing difficulties, gastrointestinal tract, skeletal system) and psychological (death of a partner, loneliness, etc.), changes, which are usually related to age [1].

Dementia patients are particularly affected. The related nutrition deficiency – proteins, vitamins (B1, B6, B12, D, beta-carotene, folic acid) and mineral nutrients (calcium, iron, selenium) [2, 3] – is not only found in private households, but also frequently in retirement and care homes. Naturally enriched foods in finger food format provide a good opportunity to reduce this deficiency and at the same time increase quality of life and independence of these patients.

The goal of the project was to develop functional food that would be accepted by elderly people, and particularly by dementia patients, from both sensory and manageability perspectives.

Methodology

The nutritional situation in retirement and nursing homes was determined by means of a written survey in which 144 Swiss homes participated. The questionnaire asked for information on the topics of "nutrition and its social aspects ", "nutrition and illnesses" and "attitudes to functional food". The questions were answered by the management and nursing

staff. In the next step, suitable functional foods were developed. The basis for these was a set of nutrition recommendations for the most frequently occurring illnesses in the target groups (diabetes mellitus, hypertonia, obstipation, hyperlipidaemia, gout) [2]. In other words, the products were to contain a minimum of sugar, fat, cholesterol, and salt, but a high amount of roughage (dietary fibre).

Acceptance testing of the products was carried out in two homes with dementia patients. As direct questioning of the residents was not possible due to their state of health, the products were presented to the residents for consumption and their reactions documented by the nursing staff.

Results

The survey of retirement and nursing homes showed that 85% take various measures to improve the atmosphere in the dining rooms (table decorations, table grouping, flowers and plants etc.). These small changes had a positive effect on food consumption. More than half of the homes (57%) offer a selection of meals (meal of the week, salad plates, various accompaniments); 96% change their menus weekly. The choice of evening meals (often cold dishes such as coffee with rolls, cold meat plates, birchermuesli or salad plates) is greater than at lunchtime. In addition, special meals are provided for those with diabetes, adiposity or complaints of the gastro-intestinal tract (in 85% of the homes for lunch and in 77% for evening meals).

Residents are involved in planning the meals in 109 (78%) of the homes. This takes place at more or less regular intervals in meetings (39%), direct discussions (27%), surveys (12%), or indirectly through feedback from the residents to the kitchen (29%).

In 10% of the homes it was stated that the residents often complained about the poor eating habits of others. In 89%, however, the residents

ate calmly at mealtimes, and in 8% they were extremely critical of innovations, according to information passed on to nursing staff.

Nine of the homes offer functional food for lunch.

The use of enriched food is considered advisable in combating illnesses caused by changes in diet, as it provides an opportunity to improve the nutritional situation. Many (61%) of the homes had a positive attitude to these products, but 40% were not prepared to use artificially enriched foods, while 10% categorically rejected the use of functional food, as they understand it to mean enriched food. This is probably due to a conservative attitude towards innovations on the part of the residents. Most popular were functional food products made from fruit (76% of the homes), followed by products made from cheese (55%), from vegetables (43%) and from sausage pieces, pasta, rice or maize balls, or potato cakes (12 %).

The functional foods developed at the ZHAW are oat brownies, dried fruit cakes, omelette cones and potato patties. The thinking behind these products was to achieve the nutritional recommendations (without enrichment), and to take into account aspects of functional foods such as size, manageability and consistency (small, manageable, not too hard, and easy to swallow).

To sweeten the oat flake brownies and dried fruit cakes, cyclamate and dried fruits were used instead of saccharose. To keep the cholesterol content of both products low, some of the egg required was replaced by a plant-based substitute. The roughage (dietary fibre) was increased by the inclusion raisins, dried fruit and oat flakes (see Table 1). Low-fat milk and fromage frais as well as plant-based egg substitute were used to reduce the fat content of the omelette cones. The salt content was also kept as low as possible by the use of dietary flavourings low in sodium, such as

herbs. Parsley and chives were the herbs used, and these also aid digestion (see Table 1).

The potato patties were produced without plant or animal fat, or oils. The firmness of the product was achieved by the high proportion of potato, which also has a low fat content but is high in dietary fibre. Linseed was used to increase the amount of roughage (dietary fibre). The salt content was also kept to a minimum by the use of herbs, spices and dietary flavourings low in sodium (see Table 1).

The nutritional values of the products are shown in Table 2.

To determine the dementia patients' acceptance of the products developed, a popularity test was carried out in a retirement and nursing home. The two sweet products were presented on plates as snacks in three different highly-frequented locations (corridor, recreation room, dining room) in the morning and afternoon on four days. The two savoury products were also offered on four days, but on a separate plate at lunch (two pieces of each product).

In 31% of the tests all the dried fruit cakes were consumed and in more than half of the tests (62%) approximately 10 of the 20 products offered were eaten. In 92% of the tests half of the oat flake brownies were eaten and in only 8% were all of them consumed. The number of products consumed varied between the three locations where they were placed, the corridor proving to be the least popular. In 38% of the testing phases none to a few of the sweet snacks were eaten and in 62% half (from a total of 20 per product) were consumed. In the dining room most products were consumed (in 23% none to few, in 31% half, and in 46% many to all). Consumption in the recreation room was found to be higher than in the corridor, but only in 38% of the testing phases were many to all of the products eaten. The residents showed a slight preference for the dried

fruit cakes, which could be seen from the frequency of consumption, i.e 60% of them consumed the product more than once, compared to 33% for the oat flake brownies. The 'hoarding' observed can primarily be attributed to the clinical picture of the residents. (Figure 1)

The nursing staff explained that the products needed to be a certain size for the residents to handle them without difficulty and commented that giving residents the opportunity to have something between meals would be advantageous. The way the savoury products were presented (as an accompaniment to lunch) was often confusing for the residents. They did not know exactly what to do with them or how they should eat the products. (This applied to 69% of the residents; the figure for sweet functional foods was only 7%.) In addition, the products had to be pointed out to half the residents several times; for 43% only one single explanation was necessary. More than half the residents (63%) ate both of the omelette cones, 38% just one. Both potato patties were eaten by 82% of the residents and 18% consumed only one. The quark filling in the omelette cones caused some difficulties, as it tended to be pressed out during consumption. According to the nursing staff, both products were not really suitable as accompaniments to regular meals, as the reactions of the residents had already shown. Moreover, the fillings should be more piquant.

Conclusions

The high acceptance of sweet functional food products can very probably be attributed to the existing profile of such products. The survey showed that savoury products as an accompaniment to a regular main meal are not well accepted, and for dementia patients this 'doubling' is confusing rather than helpful. Therefore, it makes more sense to offer a complete functional food meal. In this way the residents retain part of their independence for a longer period. The workload of the nursing staff would also be reduced by functional food meals, as a greater proportion of the

residents would no longer be dependent on the help of others when eating. Not only social, but also nutritional-physiological aspects should be considered.

The use of finger food to prevent nutrition-related illnesses is recommended on account of the potential variety of the products; depending on the intended use, different products can be chosen. If a retirement or nursing home decides to introduce functional food, certain points should be borne in mind to ensure success. The residents and their relatives must be informed of the coming change at an early stage, and the reasons for, and expected results of the innovation pointed out to them. Only through open communication can widespread acceptance of functional food meals in homes be achieved.

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Table 1: Ingredients of the finger food products developed

Product	Ingredients
Oat flake brownies	Eggs, egg substitute, raisins, cyclamate, cocoa powder, oat flakes, flour, baking powder
Dried fruit cakes	Eggs, egg substitute, cyclamate, sunflower oil, raisins, dried prunes, cinnamon, lebkuchen spices, flour, baking powder
Omelette cones	Flour, oat flakes, diluted milk, eggs, egg substitute, herbs, salt, dietary flavourings
Potato patties	Eggs, egg substitute, potato powder, linseed, herbs, salt, dietary flavourings, nutmeg, cornflour

Table 2: Nutritional value of the finger food products developed, by piece

	Dried fruit cakes (13 g)	Oat flake brownies (10 g)	Omelette cones (15 g)	Potato patties (10g)
Energy value	135 kJ (32 kcal)	110 kJ (26 kcal)	77 kJ (18 kcal)	66 kJ (16 kcal)
Protein	0.9 g	0.8 g	1.3 g	1.1 g
Carbohydrate Sugar	5.6 g 2.2 g	4.1 g 1.9 g	2.0 g 0.1 g	1.4 g
Fat—of which-- --saturated fatty acids --monounsaturated FAs --polyunsaturated FAs Cholesterol	0.8 g 0.03 g 0.1 g 16.2 mg	0.7 g 0.01 g 11.6 mg	0.6 g 0.1 g 4 mg	0.7 g 6.8 mg
Roughage (dietary fibre)	0.2 g	0.2 g	0.2 g	0.1 g
Salt			0.03 g	0.03 g
Calcium			2.4 mg	0.6 mg
Potassium	1.3 mg	1.2 mg	0.7 mg	2.9 mg
Magnesium		1.7 mg	0.02 mg	0.1 mg
Phosphorus	0.2 mg	0.2 mg	0.2 mg	0.5 mg
Chloride			0.1 mg	0.4 mg

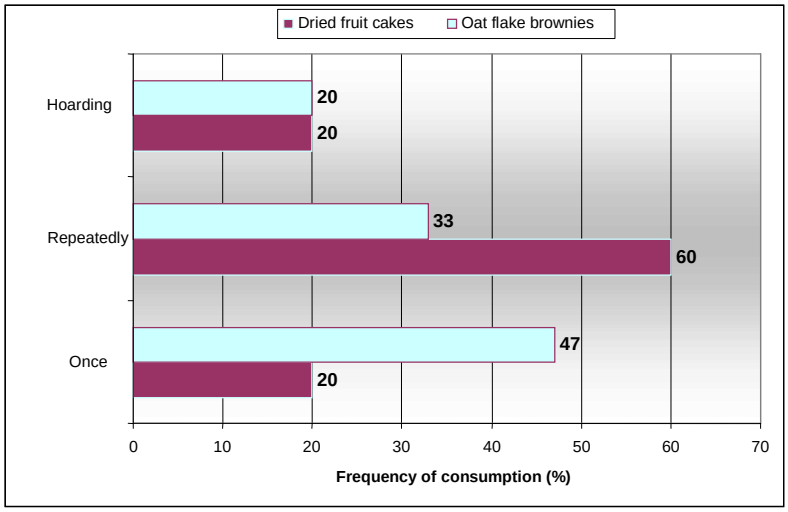

Figure 1: Frequency of dried fruit cake and oat flake brownie consumption

European Research on Functional Effects of Dietary Antioxidants (EuroFEDA)

http://www.ifr.ac.uk/EUROFEDA/default.html

By Siân Astley, Institute of Food Research, Norwich Research Park, Colney, Norwich NR47UA

e-mail: sian.astley@bbsrc.ac.uk

The EuroFEDA project (EU-QLK1-1999-00179) was supported through the European Union's Fifth Framework Programme for Research and Technological Development under the Sub-programme 'The Quality of Life and Management of Living Resources', and ran from January 2000 to December 2002. The primary aim of EuroFEDA was to review European antioxidant research under the headings of bioavailability and metabolism, biomarkers, and gene induction and mitochondrial function. Secondary goals were to establish areas of research that were missing and propose future research priorities.

Health and ageing

Major health problems associated with ageing include cardiovascular disease (CVD), cancer, the onset of blindness, and dementias. Although we know family history (genes) will influence whether we get these diseases or not, the importance of lifestyle and environmental factors cannot be under-estimated. We know that consumption of a balanced diet with a high proportion of cereals/grains, fruits and vegetables, and some fats and oils from plant sources (e.g. olive oil) reduces the risk of diseases associated with ageing. This benefit is associated with the high content of vitamins and other bioactive plant chemicals (e.g. plant polyphenols). These dietary compounds support endogenous processes limiting the

harmful effects of reactive oxygen and nitrogen species (ROS), thus minimising damage to cellular structure and function and, therefore, slowing down the ageing process.

Antioxidant dietary supplements

These are common place and are consumed in ever-increasing quantities. The theory being that if these compounds are beneficial, then any inadequacy in the diet might be recovered by taking them as supplements. Whilst there is no evidence that these isolates (single compounds in a capsule) do any harm at dietary levels, and they may prevent deficiency in some cases (e.g. folate in early pregnancy), there is little evidence that they offer the same benefits, in terms of optimal health, as compounds sourced from the diet. Supplements taken above dietary levels may even be harmful. The idea that because a little of something from the diet is good for you does not extend to more of the same from an isolated source. The fact that these compounds are natural does not mean they are safe in all circumstances. For example, digitoxin (Digoxin™) is a naturally occurring plant chemical used in small quantities to treat some heart conditions. As a pharmaceutical product, it is responsible for saving hundreds of lives but it is also highly toxic if taken in excess.

Evidence to support health benefits and identify any potential risks has to be secured before public health bodies can make recommendations. Although higher intakes of foods rich in dietary bioactives and high plasma concentrations of the same or related compounds are associated with reduced morbidity and mortality, benefit from increased intake either individually or in combination as isolates in the prevention of age-related diseases has not been demonstrated. Many arguments have been put forward to explain why these experiments have failed to show an effect consistent with the epidemiology, but few have addressed the underlying and fundamental problems with the design of such studies, which include:

- Selection of the control (apparently healthy "normal" individuals) and test groups
- Validity of the comparison between short-term intervention studies and risk-benefit over a life-time
- Liberation from food, absorption, digestion, metabolism and excretion of bioactive compounds
- Whether biomarkers have been used appropriately
- Understanding of what is normal variation in biomarkers, and what are indicative of health or disease
- Consistent and rational explanation for the effects measured

Reactive oxygen species (ROS)

One feature that may underpin ageing and the onset of age-related disease is damage caused by ROS. Oxidative stress may arise from excess production of ROS or from a lack of regulation caused by reduced capacity or absence of normal control mechanisms. ROS are essential to our metabolism having a role in the generation of energy, chemical signalling and detoxification, and the immune system. However, if as a result of environment or other factors, regulatory mechanisms fail or are overwhelmed oxidative damage accumulates. Eventually cells give way to structural and functional changes, which we observe as the effects of ageing including the development of disease.

EUROFEDA brought together many of the leading researchers from academia and industry in Europe, and their findings are summarised below. Some of the issues highlighted were addressed through the EU Sixth Framework Programme, particularly projects in priority five. Many of these projects are using post-genomic technologies and information gained from the human genome project to understand better the complex relationship between us, the food we eat, and our long term health.

Summary of the major findings of EuroFEDA

- There is no evidence to support the view that any one bioactive compound from our diet is more essential than another. The protective effects of diet, specifically higher consumption of fruit and vegetables, cereals/grain and plant-derived oils and fats, are likely to be explained by a number of dietary components, lifestyle choices and life-stage.

- Diet can prevent or delay the development of many chronic age-related diseases. Bioactive compounds cannot, however, cure disease, make diseased cells/ tissues healthy again or prevent altogether complex diseases.

- We do not know whether bioactive compounds should be consumed within the diet or given as supplements to individuals at particular risk,

or the most appropriate dose that will provide health benefits for the general population without additional risk.

- Biomarkers with a proven link to specific diseases are needed, which means that current biomarkers should be improved but also new methods should be developed such as those offered by post-genomics technologies.

- We do not yet understand whether dietary compounds act via simple chemical reactions or complex biochemical pathways, or both. Understanding this has implications for risk as well as benefit and we need to examine the effect of whole diets over longer periods of time as a priority.

- Much more information about food composition is essential. This should be made widely available through modern communication routes (e.g. on-line). We also need to know how processing and preparation influence food compounds and their liberation, absorption, digestion, metabolism and excretion.

- Functional foods designed in theory to confer specific health benefits have increasing appeal. However, we do not know yet know what effects these foods may have, who they may benefit, or what risks they represent.

EUROFEDA also identified areas for future research. The nature of the challenges facing nutrition research means that these require skills from many different fields of expertise as well as support from national and international funding bodies. Without this information, the food industry will not be able to make claims that can be substantiated, and consumers will not have the opportunity to make dietary choices that could have major health benefit, and which are underpinned by scientific evidence.

Bioavailability and metabolism (or what, where, and how?)

Wilhelm Stahl (Task Group Co-ordinator)[18], Henk van den Berg (deputy)[23], John Arthur[28], Aalt Bast[14], Jack Dainty[20], Richard M. Faulks[20], Christine Gärtner[4], Guido Haenen[14], Peter Hollman[26], Birgit Holst[20], Frank J. Kelly[17], M. Cristina Polidori[18], Catherine Rice-Evans[31], Susan Southon[20], Trinette van Vliet[30], José Viña-Ribes[6], Gary Williamson[20], Siân B. Astley[20]

To understand how dietary antioxidants, or more importantly diet and the foods in it, prevent disease, it is essential that we know: (1) what compounds are in food; (2) where they are in the food and in what form; (3) how they are released and what helps or prevents their liberation on consumption; and (4) how much is absorbed, where does it go in the body, and what does it do normally or additionally.

What we do not know:

- Factors that influence the availability of dietary compounds
- Fate of dietary compounds including whether they are metabolised (changed during digestion and absorption), where they act in the body or what makes them active
- Relationship between accessible sites (e.g. white blood cells) and target sites (e.g. gastrointestinal tract),
- Best or most suitable foods to include in our diet to ensure that the maximum amount of any given compounds is available without creating any additional risk
- How genetic difference between people and habitual dietary mix affect each of the other factors

What we have learned:

- Type of food selected, whether it is eaten raw or processed and/or cooked, all strongly influence how much of a compound is bioavailable

- Some dietary components are changed during absorption, others are not. Some of these metabolites are more active than the parent compounds whilst others are less active or display different activities
- Levels of bioactive compounds (if present) in plasma are not informative regarding tissue concentrations

We need to know more about:

- Food – (1) compounds present; (2) form (isomers, complexes); and (3) location and orientation
- Affects of processing and preparation on release and uptake
- Fate of food compounds before, during and after digestion, and the influence of source (e.g. raw versus cooked)
- Factors affecting bioavailability such as biochemical, physiological, physicochemical interactions; habitual mix of the diet; and individuals (life-stage and life-style) as well as genotype
- Methods – (1) improved selectivity and sensitivity of current methods and develop new non-invasive techniques for assessing metabolism, degradation and excretion; (2) establish the relationship between target sites and easily accessed alternatives such as blood
- How source (supplements versus food) affect absorption and bioactivity; how individual foods and the whole diet interact to affect absorption etc.; and the potential risks of increased intakes

Only when the advanced techniques have been developed and all this information is available, we can examine bioactivity (what the compounds actually do) in well-designed trials with human subjects. Ultimately, we hope to determine dose effects at target site in order to identify optimal doses of dietary components, sourced from food, for individuals and specific groups.

Biomarkers (or changes in molecules?)

Helen R. Griffiths (Task Group Co-ordinator)[24], Lennart Møller (Deputy)[22], Grzegorz Bartosz[13], Aalt Bast[14], Carlo Bertoni-Freddari[15], Andrew Collins[28], Stefan Coolen[1], Guido Haenen[14], Anne-Mette Hoberg[25], Steffen Loft[21], Joe Lunec[16], Ryszard Olinski[29], James Parry[2], Alfonso Pompella[9], Henrik Poulsen[25], Hans Verhagen[1], Siân B. Astley[20]

In order to measure to what extent a biological system is altered by oxidative stress or diet we need biomarkers. Although symptoms of a disease are essentially biomarkers, they occur too late in the disease process to be useful. Ideally, a series of biomarkers is needed; up to the onset of symptoms and then for each stage of the disease. At the moment many biomarkers can tell us about damage to molecules, changes in function (e.g. blood flow or brain power) or the development of specific stages in disease (e.g. lens opacity for cataract development and fatty-plaques for cardiovascular disease). They do not determine whether someone is at high risk of a particular disease later in life or for that matter whether diet has helped prevent damage that might lead to disease or optimal intake for a given sub-group or individual.

A valid biomarker must be:

- Stable (i.e. not change as a result of collection or storage)
- Representative of the balance between oxidative damage, generation and repair
- Not subject to contamination (e.g. likely to occur in the food we eat)
- Easily obtained from a surrogate source (e.g. blood sample) that reflects the levels in a target tissue (e.g. prostate or lung)
- Sensitive to oxidation and protection from antioxidants in a dose dependent manner

The assay used to measure biomarkers should be specific, sensitive, reproducible and robust, and the results within an appropriate range

based on the limits of detection. In addition, expected values should be for each assay, and need to be representative of age group, sex and ethnicity.

EuroFEDA concluded that approximately half of antioxidant studies used an appropriately validated method, but of those that did, the majority showed evidence of benefit. Further, benefit was more frequently observed in people who were under oxidative stress at the start of the study (e.g. smokers).

Recommendations for studies:

- Several validated and biologically relevant markers should be used in a single study
- Trial design and study power are crucial to success
- Both benefit and risk should be evaluated
- Volunteers must stay healthy throughout a study
- The suitability of a biomarker should be determined separately for healthy individuals and those with a disease like cancer, and it should be remembered that the same biomarker may not be suitable at each stage or for every disease
- Validation of methods should be by exchange of samples between laboratories and comparison of the results obtained with a view to minimising differences
- Normal values for biomarkers should be measured in apparently healthy people as well as those with age-related diseases, at each stage of the disease. The normal effects of ageing should also be determined
- In addition to the relationship between biomarker formation and diet, genotype should also be considered
- The importance of particular types of cell damage should be examined; some may be more harmful than others

Antioxidants, reactive oxygen and nitrogen species, gene induction and mitochondrial function (or how does it all work?)

Malcolm J. Jackson (Task Group Co-ordinator)[12], Sergio Papa (deputy)[10], Juan Bolaños[5], Richard Bruckdorfer[7], Harald Carlsen[19], Ruan M. Elliott[20], Jacoba Flier[11], Helen R. Griffiths[24], Simon Heales[8], Birgit Holst[20], Michele Lorusso[10], Elizabeth Lund[20], Jan Øivind Moskaug[19], Ulrich Moser[27], Marco Di Paola[3], M. Cristina Polidori[18], Anna Signorile[10], Wilhelm Stahl[18], José Viña-Ribes[6], Siân B. Astley[20]

Reactive oxygen and nitrogen species (ROS and RNS) are essential signals, responsible for changes in cell function, growth and development, and death. Since antioxidants react with ROS, the fact that ROS are key to health as well as potentially harmful has important implications for understanding the roles and requirements for the bioactive dietary compounds, as they could interfere inappropriately with these essential cellular processes. Very few studies have looked at both sides of this phenomenon, but knowing the relative importance of both oxidants and antioxidants is crucial to understanding how diet might delay ageing and prevent age-related disease.

Key conclusions

- ROS/ RNS act as key communication systems in the body
- Mitochondria, which are responsible for energy production in cells, are also a major source of oxidants and are highly susceptible to oxidative damage
- Some of the effects of ROS/ RNS are protective and it is not clear (i) what effect antioxidants may have on these or (ii) whether it is appropriate to attempt to change them
- Changes in the expression of genes that are stimulated by ROS can be modified by antioxidants in laboratory studies but we do not

know whether dietary compounds have the same or different effects from person to person.

Future research needs – we need to know more about

1. How individual compounds act because they may impact on many different biological processes
2. Production of ROS and responses to them, particularly patterns that are associated with health and those that typically result in disease
3. Risk: benefit for individual compounds and complex foods
4. Changes in the behaviour of mitochondria that are unrelated to energy supply, and the effects of diet on these changes

The EuroFEDA partner organisations were:

1. Bioanalysis & Biomarkers, Unilever Health Research Institute, Unilever Research Vlaardingen, The Netherlands
2. Centre for Molecular Genetics & Toxicology, School of Biological Sciences, Prifysgol Cymru, Swansea, UK
3. Centre for the Study of Mitochondria and Energy Metabolism, C.N.R.Bari, Italy
4. Cognis Deutschland GmbH, Düsseldorf, Germany
5. Departamento de Bioquimica y Biologia Molecular, Universidad Salamanca, Spain
6. Departamento de Fisologia, Facultad de Medicina, Universidad de Valencia, Spain
7. Department of Biochemistry and Molecular Biology, Royal Free and University College Medical School, London, UK
8. Department of Clinical Biochemistry, National Hospital, University College London, UK
9. Department of Experimental Pathology, University of Pisa Medical School, Italy
10. Department of Medical Biochemistry and Biology, Università di Bari, Italy

11. Department of Medical Pharmacology, Vrije Universiteit, Amsterdam, The Netherlands
12. Department of Medicine, University of Liverpool, UK
13. Department of Molecular Biophysics, University of Lodz & Department of Cell Biochemistry and Biology, Pedagogical University of Rzeszów, Poland
14. Department of Pharmcology & Toxicology, Faculty of Medicine, University of Maastricht, The Netherlands
15. Dipartimento Richerche Gerontologiche, I.N.R.C.A., Ancona, Italy
16. Division of Chemical Pathology, LRI NHS Trust, Leicester, UK
17. Environmental Research Group, School of Health & Life Sciences, King's College London, UK
18. Institut für Physiologische Chemie I, Düsseldorf, Germany
19. Institute for Nutrition Research, Oslo, Norway
20. Institute of Food Research, Norwich, UK
21. Institute of Public Health, University of Copenhagen, Denmark
22. Karolinska Institute, CNT Novum, Stockhom, Sweden
23. Netherlands Nutrition Centre, Den Haag, The Netherlands
24. Pharmaceutical Sciences, Aston University, Birmingham, UK
25. Rigshospitale, University Hospital, Copenhagen, Denmark
26. RIKILT-DLO, Wageningen, The Netherlands
27. Roche Vitamins Europe Ltd., Basel, Switzerland
28. Rowett Research Institute, Aberdeen, UK
29. The L. Rydygier Medical University, Department of Clinical Biochemistry, Bydgoszcz, Poland
30. TNO Nutrition & Food Research, Zeist, The Netherlands
31. Wolfson Centre for Age-Related Diseases, Antioxidant Research Group, Guy's, King's and St Thomas's School of Biomedical Sciences, King's College London, UK

RUBINI ® - A Food Supplement from elderberries

By Werner Pfannhauser, Institute of Food Chemistry and –technology, Graz University of Technology, Austria
Email: Werner.pfannhauser@tugraz.at ; beratungskanzlei@pfannhauser.at

Sambucus nigra is a species of elder native to most of Europe, northwest Africa and southwest Asia. It is most commonly called just Elder or Elderberry, but also Black Elder, European Elder, European Elderberry, European Black Elderberry, Common Elder, or Elder Bush when distinction from other species of Sambucus is needed. It grows in a variety of conditions including both wet and dry soils, primarily in sunny locations. Since ancient times in Central Europe elderberry plants have been used as a so called "pharmacy of the farmer". For example, flowers, leaves, bark and the berries have been used for many purposes in folk medicine. Amongst others, an infusion of flowers functions as a fever depressing pharmaceutical. The berries are normally consumed as fruit juice, in comfitures as well as ingested directly. One of the disadvantages of elderberries is that the wild berry bushes carry ripe, semi-ripe and unripe berries on the same bush at the same time. Semi-ripe and unripe berries contain Sambunigrin, a cyanogenic glucoside which tastes unpleasant and sometimes causes vomiting. Therefore, picking berries from wild shrubs can lead to mixed quality.

"Type Haschberg" elderberries

In Austria, in an Experimental Station for Horticuture (Klosterneuburg close to Vienna) a breed of elderberry was cultivated that grows as a small tree. All the berries of the breed called "Type Haschberg", - which is the name of a hill close to that Experimental Station, - ripen at the same time and the berries are larger in size than the wild ones. The plant is cultivated in the shape of small trees and yields are 28 – 40 kg / tree. A

density of 500 trees per hectare produces heavy crops of 15 tons of berries.

With flowers

With berries

The production of this cultivated elderberry is facile at suitable locations. Elderberry prefers slightly humid, rich, deep and porous soils. The preferred region for cultivation of elderberry in Austria is located in Southern Styria. The region has a mild, humid and sunny climate. Due to increasing plantation and high yields, the conventional use as comfiture or fruit juice could not absorb the yield produced in the 1990s. The Grower Association 'Steirische Beerenobst Ltd' promoted and sponsored a research project on alternative use of elderberry. Two options were taken into account: (i) flavour concentrates from elderberry flowers; and (ii) use of the deep red colour of the berries for as natural food colorants.

Concentrating the anthocyanins

Within a research project conducted at the Institute of Food Chemistry and –Technology, at Graz University of Technology, Austria, a concentration process of the anthocyanins as a red colour source was developed. The juice was made partly free from sugar, concentrated 20-fold, and spray dried using a special type of maltodextrin. The anthocyanin content is standardised at 14%. This technology results in a dry powder that can be used as a natural colorant in the food industry.

Antioxidant status

Research was also conducted to determine the antioxidative potential of the elderberry powder. Elderberry fruits are an excellent source of anthocyanins, vitamins A and C, and a good source of calcium, iron and vitamin B6. Natural anthocyanins occur as glycosides (i.e. attached to a sugar molecule) while anthocyanidins are aglycones of anthocyanins. The most important polyphenols found in elderberry are anthocyanins, mainly cyanidin 3-glucoside and cyanidin 3-sambubioside. Anthocyanins from elderberries are acylated, thus making them more stable to light, which, in turn,

make them more suitable for processing. Cyanidin, a main constituent of the polyphenol–group present in elderberry has one of the highest antioxidant activities. By oral administration of elderberry extract, cyanidins are absorbed in their glycosidic forms. However, the exact form under which elderberry anthocyanins are absorbed by humans is still a matter of debate. Most evidence suggests that they are absorbed in their glycosidic form. The antioxidative capacity of the elderberry powder is considerably higher than Vitamin C and rates well when compared to other fruits such as cranberry, mulberry, and blueberry. Investigations on the metabolism and stress tolerance function were also conducted (see literature). As a result an antioxidative functional food, marked as a food supplement, was produced in Austria. Selenium and Zinc was added to the anthocyanin preparation to enhance the functionality and the antioxidative properties. It is well known that antioxidants of several types working together in the body prevent adverse effects of excessive oxidants caused by stress. The elderberries used to give the supplement are ecologically produced to guarantee highest quality. The product brand name is "Rubini". The rights for the brand name **RUBINI** ® are with the Wellness Company, Vienna, while the intellectual property rights are with Pfannhauser Consultants, Vienna.

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More information

Contact O.Univ. Prof. Dr. Werner Pfannhauser, Institute of Food Chemistry and – technology, Graz University of Technology, A-8010 Graz, Petersgasse 12/2 *and/or* Pfannhauser Consultants
A-1180 Vienna, Kreuzgasse 79, *and/or* The Wellness Company, Jochen Rindt Str. 23, 1230 Vienna, Austria,

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Unter der Leitung von Univ. Prof. Dr. W. Pfannhauser, beschäftigen sich Wissenschafter seit einigen Jahren intensiv mit den vielfältigen Wirkmechanismen des Holunders. Im Mittelpunkt des Interesses stehen dabei die Inhaltsstoffe der schwarzen Beeren und ihr positiver Einfluss auf unsere Abwehrkräfte und Gefäße.

WAS SIND FLAVONOIDE?

In der Holunderbeere finden sich neben Vitaminen, Mineralen und Enzymen, sogenannte Flavonoide. Dabei handelt es sich um Pflanzennährstoffe, die ein wertvoller Bestandteil unserer Nahrung sind. Diese bioaktiven Substanzen beeinflussen eine Vielzahl von Stoffwechselprozessen im Körper, u.a. Oxidationsvorgänge, Gefäßpermeabilität, Immunmechanismen und Entzündungsprozesse.

Zu den Flavonoiden zählen auch die Anthocyane, jene Pflanzenstoffe, die den Holunderbeeren ihre intensive rote Farbe geben.

Rutin: an effective component of functional foods

By Ivana Paulíčková, Food Research Institute Prague, Czech Republic
e-mail: I.Paulickova@vupp.cz

Cardiovascular disease is the number one cause of death globally and is projected to remain the leading cause of death. Although typically considered a disease of developed countries, its incidence is increasing in the developing world. If appropriate action is not taken, by 2015 an estimated 20 million people will die from cardiovascular disease every year, mainly from heart attacks and strokes (1).

In recent times, especially in all industrially developed countries, consumers are becoming more interested in foods which offer an added value in terms of health benefits. Fresh or processed food claimed to have a health-promoting or disease-preventing property beyond the basic nutritional function of supplying nutrients is called functional food. The term was first used in Japan in the 1980s, where there is a government approval process for functional foods, called Foods for Specified Health Use (FOSHU) (2). The consumption of functional foods with an increased content of rutin may be a way of reducing the risk of cardiovascular diseases in the population.

Rutin

Rutin is a member of the bioflavonoids, a large group of phenolic secondary metabolites of plants that includes more than 2,000 different known chemicals. Rutin is an important therapeutic substance that favourably influences the increase of blood vessel elasticity and the treatment of circulatory disorders and

atherosclerosis. It reduces blood pressure, stimulates vitamin C utilization and has antioxidant activity (3,4,5,6).

Rutin, a flavonoid glycoside (3-O-beta-rhamnoglucoside---a form of quercetin) has been found to occur abundantly in plants, but only a small number of plant materials contain quantities sufficient for industrial extraction (*Sophora japonica, Eucalyptus macrorrhyncha,* buckwheat*) (7).* Rutin was first discovered in buckwheat by Schunck in the 19th century; he stated that 240 g of the glucoside could be isolated from 30 pounds of fresh leaves (8).

Rutin in buckwheat

Approximately 50 years ago, buckwheat was cultivated as a rich source of rutin for herbal drug production in the United States of America. At present, buckwheat is still considered a major dietary source of rutin. Buckwheat (pseudocereal) is a dicotyledonous plant belonging to the Polygonaceae family. Common (*Fagopyrum esculentum* Moench.) and Tartary buckwheat (*Fagopyrum tataricum* Gaertn.) are the only two of the many buckwheat species known that are cultivated for human consumption. Buckwheat is a natural functional food, because it positively affects the human organism biologically (for example low glycemic index and reduced capillary fragility) without the necessity of adding any other components. Buckwheat is uniquely rich in proteins (12-15%) and essential amino acids, such as lysine (5-7%), that are deficient in major cereal crops, but also contains an abundance of lipids, fibres, minerals (zinc, manganese, selenium, iron, phosphorus, and copper), and vitamins (B1 and B2) (9,10,11,12,13,14).

Buckwheat is native to temperate East Asia and was grown in China before 1000 AD; it is now grown in many areas of the world. Although buckwheat production is concentrated in China, Japan and North America, it is also produced in Europe, India, Tibet, Tasmania, Australia, Argentina, Bhutan and numerous other

countries. The name "buckwheat" comes from the Anglo-Saxon words *boc* (beech) and *whoet* (wheat) because the seed resembles a small beech nut. The presence of rutin in buckwheat plants is one of the main reasons for the production of different kinds of buckwheat foods.

Buckwheat usage

The dehulled seed, or groat, is used in breakfast cereals and milled into grits. Roasted groats are called kasha, and are sold in whole and granulated forms. Both kasha and groats can be baked, steamed, or boiled for nutritious alternatives to potatoes and rice. Buckwheat flour has numerous uses. It is used in pancake mixes as well as in various breads. It is often blended with wheat flour for use in bread, pasta products, and some breakfast cereals. The Japanese mill buckwheat seeds into flour for use in the production of soba noodles, which are a major part of the Japanese diet. In Eastern Europe, buckwheat flour is used in cooking similar to wheat flour. Bread, cakes and dumplings are made with the addition of wheat flour. Buckwheat flour is used alone in some dishes, such as polenta and zganci. Buckwheat flour in bread mixes comprises only 30% to 40% of the total. It may also be used in desserts, ice cream, dietetic foods, pancake mixes, canned meat products, canned vegetable products and dried breakfast cereals. Pasta produced from a mixture of wheat and buckwheat flour has been characterized to possess shorter cooking time. Buckwheat can be used to produce extruded cereal and snack products. Extruded buckwheat products are of very high nutritional quality when compared with products extruded from wheat (15). The specific character of the proteins allows buckwheat to potentially be used in extruded products targeted to special nutritional needs. As buckwheat does not contain gluten, it is a common supplement for patients with coeliac disease. Buckwheat intolerance is rare among

patients with gluten intolerance alone, but more common in those with coeliac disease combined with other food allergies. Allergic reactions are caused by ingestion of allergenic buckwheat proteins (16). Other products made from buckwheat are green buckwheat tea, buckwheat beer and vinegar, spirit, buckwheat floral honey, buckwheat sprouts and fresh green plant parts used as a vegetable.

Buckwheat fractions

Dried buckwheat tops

Buckwheat bread

Rutin content in buckwheat depends on species, harvest conditions, and the environmental conditions under which it is produced (17, 18).

Common buckwheat is the most widely consumed buckwheat species with its advantages of sweet taste and large, easily de-hulled seed. Researchers are very interested in using Tartary buckwheat because its content of rutin and other bio-active compounds is much higher than in common buckwheat, which has been traditionally utilized throughout the world. Tartary buckwheat has the disadvantages of bitter taste, small seed size, and a hull that firmly adheres to the testa thus making de-hulling extremely difficult.

The content of rutin differs in different parts of the buckwheat plant (*Fagopyrum esculentum* Moench) in ascending order from hulled grains, unhulled grains, germinated hulled grains, root, germs, stalk, flower, young plants and tops up to leaves. The highest content of rutin can be found in buckwheat leaves, but buckwheat tops are much easier to use as a source of rutin, considering the costs connected with the harvesting technology. Dried buckwheat tops contain about 100 times more rutin than grains. The possibility of using dried buckwheat tops as a functional component in mixes for the preparation of extruded and bakery products was verified at the Food Research Institute Prague. The recipes for preparation of breads, rolls, gingerbread, poppy-seed cake and dry side dishes were developed. For example, eating four slices of baked bread containing buckwheat tops would supply approximately 20 mg of rutin. This material also binds water very well, keeping bread crumb soft. From the viewpoint of sensory acceptance, in most products 1g of dried buckwheat tops can be conveniently added to 100g flour (19,20).

The nutritional and medical qualities of rutin make buckwheat a desirable constituent of a variety of functional foods.

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Seaweed the new "superfood"?

By Sarah Hotchkiss, Angie Trius of CyberColloids ltd, Cork, Ireland and Duika Burges-Watson of Newcastle University, UK

For years the food industry has sought out new and innovative ways of enhancing a healthy diet. Often in this quest companies and academics get excited about new extracts from various plants and vegetables. However, since the advent of the Novel Foods Directive, such new ingredients will have major barriers to cross before commercialization can be realized.

SO why not consider the rediscovery of new uses for traditional foods as a source of nutrition. In particular, lets consider seaweeds or sea vegetables which are increasingly valued as a "new" functional and health ingredient.

"J is for Jellies: Hot langoustine jelly served with chervil cream at le Champignon Savuage in Cheltenham"… "U is for Umami: boost the savoury flavour profile with the fifth taste sensation". Two of the key 'A-Z tastes of things to come' listed in the December 2006 Observer Food Monthly special edition on the 'future of food' involve new uses for seaweed. The new found palatability of seaweed in the west is being given a kick start by two of the world's greatest chefs

– Ferran Adria ('E' is for El Bulli – Adria's acclaimed Spanish restaurant) and Heston Blumenthal ('B' is for Blumenthal – the proprietor of the Fat Duck). The reputation of these chefs is creating a burgeoning interest amongst foodies worldwide in the functional properties of seaweed extracts that enable high temperature jellies to remain solid, and the flavour enhancing properties of seaweeds for all manner of uses in cooking. Yet despite the new fashion for using seaweed, these chef's have only touched the tip of an iceberg particularly given contemporary concerns about 'healthy diets' and seaweed as a superfood.

If you were asked the following question "*Weight for weight, what foodstuff contains more iron than sirloin steak, more fibre than prunes or bananas and more calcium than cheese??* Would you have answered *"Seaweed"*? Probably not, but seaweeds are highly nutritious and are attracting increasing attention as a valuable food source.

Nutritional components

Described as "the most nutritious form of vegetation on this planet" they contain almost all of the important nutritional components in levels that often far exceed their terrestrial counterparts, vegetables. Anecdotal claims for the nutritional and holistic benefits of incorporating seaweed into a balanced diet stretch as far back as 2700 BC but scientific research is rapidly accumulating evidence to support these claims. It is known that seaweeds contain numerous bioactive substances that have been shown to lower cholesterol, reduce blood pressure, promote healthy digestion; and antioxidant activity. Add to this the fact that they are virtually fat and calorie free and it is easy to see why seaweeds are building a reputation as the new "superfood".

Edible seaweeds

So, what seaweeds are edible? In theory, all seaweeds are edible but whether they are palatable is a different matter. One of the challenges for the widening of seaweed consumption in Europe is that of palatability. As many as 500 species of seaweed are harvested or cultured and every year millions of tonnes are used to supply the food industry. Asian countries in particular China, Japan and Korea are the primary users of seaweed for food. In 2002 a staggering 8 million tonnes was used to supply China alone.

Asian cuisine is rich in dishes that use fresh and dried seaweed directly as "sea vegetables" or as flavourings in soups, stews and sauces. More than twenty species are commonly used but kombu (*Laminaria* spp.) and nori (*Porphyra* spp) are the most popular. Nori is sold in dried sheets and is used to wrap dishes like sushi; apparently the Japanese consume around 9000 million sheets of nori per year.

In Europe, traditional uses of seaweed are not as common as in Asia but some species such as laver (*Porphyra* spp.) and dulse (*Palmaria palmata*) are found in the coastal towns of Ireland and the UK (Tab. 1). Laver is the essential ingredient of the traditional Welsh breakfast; served as little oatmeal coated patties with salty bacon and cockles. Dulse is usually sold dried in little bags like quarters of sweets. Like Marmite, the salty delicacy is not to everyone's taste, but as the Irish will testify, it's actually rather good for you

If you type a few key words into Google then you will soon discover that there is a very respectable following of seaweed food lovers. There are numerous websites extolling the health and well being attributes of seaweeds or sea vegetables; there are recipes and tips on collecting and preserving seaweeds.

Table 1. Some of the more common seaweeds found around our coastline and traditionally used as a food source

Common names	Taxonomic details	Uses	Recipe suggestions
Kelps	*Laminaria* spp. Large brown seaweeds	Commonly used in Asian cuisine for flavouring in sauces, stews and stocks	
kombu, kelp, tangle	*L. digitata*	Traditional boiled vegetable of the Hebrides. Usually sold dried in bundles, used as above	Use as a substitute for vegetables in tempura dishes Pickle small pieces of kelp and use like capers. Good in seafood pasta dishes and on seafood pizzas
Sweet kombu, sweet kelp, oarweed, sugar wrack, tangleweed	*L. saccharina*	Chewed as a sweet snack. Used in similar way to above but with much sweeter taste	
Wakame	*Undaria pinnatifida* Invasive species of kelp from Japan becoming increasingly common in European waters	Used raw in salads and as a wrapping for savoury parcels	Excellent with fish, use to wrap fish steaks but remove tough midrib. Shred fresh into coleslaws and salads.
Laver, laverbread, black butter, slouk, sloke (Europe) **Nori** (Japan)	*Porphyra* spp Red seaweed	Main ingredient of Welsh laverbread Wrapping for sushi and savoury parcels in Japan	Mix cooked laver puree with olive oil and other flavourings such as lemon and pepper for a savoury tapenade
Carragheen, Irish Moss, Dorset Moss, Iberian Moss	*Chondrus crispus* red seaweed	Gelling agent, traditionally boiled in milk for moulds and puddings. Boiled in milk with honey to sooth coughs and colds.	Good vegetarian substitute for gelatine in sweet and savoury dishes
Dulse, dillisk, creathnach	*Palmaria palmate* red seaweed	Sold sundried and eaten in Ireland as	Salty almost spicy flavour; good with

		a snack. Used raw in salads and slaws	fish and potatoes. Sprinkle dried flakes over fish dishes or used cooked in sauces and creamy potato based soups
Pepper dulse	*Laurencia pinnatifida* Red seaweed	Used as a condiment	Strong peppery flavour, use as dulse

But is any of this information backed by scientific investigation? Yes, there is strong evidence to suggest that seaweeds have the potential to be nutritionally beneficial components of foodstuffs either as wholefoods or as extracts. Typically our modern diet is high in refined and processed products and lacks the necessary levels of dietary fibre, minerals and vitamins that are necessary to keep our bodies healthy. Many of the illnesses and diseases that plague our society, the so called "*diseases of affluence or excess"* like heart disease, high blood pressure, weakened immune systems and even cancer appear to be diet related but the incorporation of seaweed into a balanced diet could help.

Gut health

Dietary fibre is needed to clear the digestive tract, protect surface membranes in the stomach and intestine against ulcers and carcinogens, and to eliminate unwanted cholesterol and salt. Weight for weight comparisons show seaweeds to contain levels of fibre that are comparable to or greater than vegetables. A 100g portion of *Laminaria digitata* contains 6.2% fibre, higher than that contained in equivalent portions of prunes, apple, banana and brown rice.

Much of the algal fibre is water soluble and some fibres are not digested in the small intestine. This aids in decreasing lower bowel transit time, improves faecal bulking and water retention, and

promotes bacterial population of the lower bowel. As the fibre in seaweed is non-starch based, it also lowers the overall ratio of fibre to carbohydrate indicating that seaweeds probably have a lower glycaemic index (GI) than vegetables.

Heart health

Several studies on the effects of seaweeds or seaweed extracts on blood cholesterol levels have found that there is an overall decrease in cholesterol for a variety of reasons. Polysaccharide effects are distinct from sterol effects in these studies. Studies using alginates have found that cholesterol absorption in the gut is reduced and this then reduces plasma cholesterol levels most likely due to the entrapment and bulking effects of the alginates. Brown seaweeds in particular contain high levels of sterols. Fucosterol has been shown to restrict the solubility of cholesterol in bile and, therefore, lower the absorption of cholesterol in the bloodstream.

High blood pressure can result from an imbalance in sodium and potassium in the body and deficiency in other minerals such as magnesium and calcium can also lead to vasoconstriction. Seaweeds typically contain high concentrations of potassium, magnesium and calcium, and have been shown to have a positive effect on regulating mineral balances and blood pressure.

Seaweeds contain many essential fatty acids, most are polyunsaturated occurring in the form of omega-3 and omega-6 lipids. The omega-3 to omega-6 ratio is closely matched, a factor that has been shown important in a balanced diet.

Antioxidants

Seaweeds contain large amounts of antioxidants and polyphenols (known as phlorotannins). Phenols and polyphenols are present in many fruits and vegetables and constitute an important anti-cancer active group in nutrition. Their role in seaweed survival is linked to

the exposure levels that seaweeds experience to UV light. Seaweeds are exposed to many of the same conditions which cause free radical formation in human bodies but appear to be relatively free from the effects of these agents. This indicates that seaweeds contain protective antioxidative defence systems and many studies have demonstrated *in vitro* antioxidant activity in them.

A number of seaweed derived polysaccharides, minerals and vitamins have also been shown to have antioxidant properties. Vitamin B 12 is usually found in animal foodstuffs but seaweeds provide one of very few plant sources of this vitamin. A 100g portion of *Ulva lactuca* can provide up to 35% of the RDA . Seaweeds are a good source of the trace element selenium which is currently attracting a lot of attention regarding its potential anti-cancer properties.

Immune system enhancement

As with other seaweed polysaccharides, there is evidence of anticoagulant activity in fucoidan fractions. In addition, there is some evidence that fucoidans can enhance vascular tube formation further enhancing interest in the cardiovascular area. Fucoidans can also inhibit the inflammatory changes induced by pneumococcal meningitis and may be a replacement for pharmaceutical anti-inflammatories.

Bone health

Seaweeds contain a high level of calcium which is normally associated with the polysaccharides, such as alginates or carrageenans. Calcium is also bound and can comprise up to 7% of the dry weight. For some calcareous seaweeds such as *Lithothamnion calcareum,* the calcium content can be up to 35%.

This form of calcium has been found to be more bioavailable than calcium carbonate used in supplements.

The challenge

Widening the use of seaweed consumption in the West is a challenge that CyberColloids ltd in Cork, Ireland has taken up. They are convinced that there is no doubt of the health benefits involved but that consumers are generally not prepared to compromise on certain food attributes like taste and aroma. As a private contract Research to Business Development company, CyberColloids is not alone in making this happen as some of the best known chefs, Blumenthal, Oliver and Ramsey, are already tempting their customers with dishes like crystallised seaweed in oyster vinaigrette, beef stew made with seaweed stock and salmon with pickled seaweed.

Here's to a healthy future!!

Further information contact info@cybercolloids.net

We thank Professor Mike Guiry, NUI Galway and Porto-muiños, La Coruña, Spain for allowing the use of their images.

Functional seafood products:-some outcomes from the SEAFOODplus project

By Mercedes Careche, Instituto del Frío (CSIC), c/ José Antonio Novais 10,28040 Madrid, Spain
e-mail: mcareche@if.csic.es

Seafood is used as a source of components to manufacture functional foods such as fish oils or protein powders from by-products, but the functional seafood production is actually limited as compared to other foods. To our knowledge, there are no commercially available farmed fish which can be regarded as a functional food for their elevated levels of components other than those with polyunsaturated fatty acids. On the other hand, seafood matrices such as fish fillets, pieces of fillets, minced fish, or *surimi* can be regarded as excellent vehicles for the incorporation of functional ingredients. In fact, there are fewer restrictions on the use of ingredients in these types of restructured products since they need not be components which are accumulated in, or produced by, the fish body as in farmed fish. Thus, there is clearly a potential for increasing the range of functional seafood products either by aquacultural production or by developing restructured or fillet-based seafood products. SEAFOODplus was a widely based Integrated Research Project supported by the EU under Framework Programme 6. It's strategic objective was to reduce health problems and to increase well-being among European consumers by applying the benefits obtained through consumption of health promoting and safe seafood products of high eating quality. SEAFOODplus had 70 partners in 16 countries and the research programme was organised in six main areas containing a total of 20 projects---see more at www.seafoodplus.org

Functional compounds and complexes

Some functional ingredients such as dietary fibres are widely used in functional foods, accounting in weight for about 50% of the total functional ingredients in the market. Knowledge of the beneficial effects of diets high in dietary fibre for the prevention of cardiovascular disease and many types of cancer has led to the development of a large market for dietary fibre–rich products. Some fibres, for example, from fruit, have in general better nutritional qualities than others such as those derived from legumes or cereals, partly because of the presence of significant amounts of specific associated compounds. On the basis of this, a new type of natural product, named antioxidant dietary fibre, has been defined, and combines in a single material the physiological effects of both dietary fibre and antioxidants.

Other new ingredients are emerging such as organo selenium compounds. Selenium is an essential micro-nutrient for the production of certain amino acids in humans and animals. Its deficiency results in diseases, whereas high amounts are toxic. Animal studies with selenium-enriched garlic or yeast have shown that it has the potential to negate certain cancers. The availability of components, such as selenate, Se-methyl-selenocystein and glutamyl-Se-methyl selenocystein, that can easily be taken up by the stomach and gut is of high importance. Selenium is present in many foods including fish.

The clinical utility of taurine in relation to cardiovascular health has been demonstrated by a number of workers and it has been shown that taurine modifies endothelial dysfunction in young smokers, and restores normal flow-mediated dilation in the brachial artery. Fish is a good taurine source and fish fillets/portions can be enriched with additional taurine.

Convenience seafood products

Convenience foods and ready-meals from fishery products have experienced a growth in wealthy countries, and there is a continuous need for new products, processes and ingredients that fulfil the needs and expectations of consumers. The technological developments have to be translated into attractive products; but technology-driven development as such may not be adequate for the market, and the demands from various consumer segments must be taken into account together with the new technological developments.

Outputs from the SEAFOODplus *Consumer Products* research team

Taking into account the above considerations, the objective of the Consumer Products sub-project in SEAFOODplus was to develop innovative functional seafood products with the quality and convenience characteristics required by target consumer groups. Twelve key scientists and their co-workers from nine different Institutions across Europe constitute this team. The project was designed with a consumer-oriented approach so that consumer studies support the development of the seafood products throughout the project.

Antioxidant dietary fibres

Some commercial dietary fibres (DFs) as well as non commercial antioxidant DFs have been used for the development of restructured seafood products. In general, dietary fibres confer the seafood matrices (including surimi or minced fish) with additional technological features that can be used in a positive way in product design. Variables such as the dietary fibre particle size, have been shown to be critical in order to make products sensorically

acceptable. Grape DF concentrates from white or red grape, from different parts of the grape by-products (skin, seeds or pomace) were introduced as a source of antioxidant DF into restructured fish products. The major advantage of these dietary fibres is that they possess notable antioxidant properties, which are able to significantly inhibit the development of lipid oxidation in frozen minced fish muscle. Sensory analysis indicated that samples of horse mackerel minced muscle, with 2% added grape dietary fibre, were very acceptable.

Taurine

The addition of taurine to tuna portions was also addressed and performed by using a vacuum tumbling procedure (taurine/phosphate solution) with a target content in the fish of *circa* 1% on a fresh weight basis (i.e. as eaten). The taurine/phosphate solution did not influence the sensory properties of the fish. The taurine enriched tuna was processed by freezing, chilling, freeze-chilling and *sous vide* cooking and showed good retention of the added taurine. Cooking tests on the frozen samples indicated that grilling gave the highest level of taurine retention followed by microwaving and steaming; the latter had a leaching effect on the taurine.

Fish has a high level of inherent functionality via its naturally occurring bioactive components, and in this context the taurine content of a number of fish species was also measured. The taurine content of four species purchased in supermarkets (eight test dates) was in the order plaice [126mg/100g wet weight (ww)], cod (93), mackerel (69) and farmed salmon (53). The relative order for the species was the same over eight test dates. Values for spot samples of a number of other species were albacore tuna (155), ray wing (128), wild salmon (53), siki shark (44), whiting (35), Greenland

halibut (28), roundnose grenadier (6) and Baird's smoothhead (5mg/100g ww). Tests with plaice indicated that chilled storage (± modified atmosphere packaging) for up to 10 days did not influence taurine content. This indicates that taurine is a stable molecule under these conditions.

Selenium compounds

Organo-Se compounds from garlic cultured with selenate were being incorporated into African catfish via dietary modulation. The first farming experiment revealed a very clear dose response relationship between Se levels in the feeds, and that in the fish fillets. Neither dietary garlic nor high dietary selenium levels had a negative affect on fish performance in terms of feed intake, feed conversion rate, and specific growth rate. Speciation of selenium in the fish fillets revealed that Se-methylselenocysteine (to which anti-carcinogenic properties are attributed) was recovered in the fillets. In a second farming trial, the required length of the feeding period prior to harvest was determined, in order to reach the target selenium concentration in the fillet without including selenium during the entire fish production period. Results from the retention and losses of nutritionally important components during household preparation of selenium-enriched African catfish showed that no general recommendation can be given for the components investigated. However, baking in aluminium foil was favourable for the retention of fatty acids and taurine, while most selenium was retained during deep frying.

More information

Peruse the SEAFOODplus website at www.seafoodplus.org for more information. Contact details for the 12 persons in the Consumer Products research team are:

Mercedes Careche (mcareche@if.csic.es), Adriaan Kole (Adriaan.Kole@wur.nl),
Fulgencio Saura (fsaura@if.csic.es), Olga Scholten (olga.scholten@wur.nl), Javier Borderías (jborderías@if.csic.es), Pedro Carmona (p.carmona@iem.cfmac.csic.es), Ronan Gormley (ronan.gormley@teagasc.ie), Edward Schram (Edward.Schram@wur.nl), Jörg Oehlenschlaeger (joerg.oehlenschlaeger@ibt.bfa-fisch.de), Leonor Nunes (mlnunes@ipimar.pt),
Edel Elvevoll (edele@nfh.uit.no), Iren Stoknes (ist@als.moreforsk.no).

Synbiotic carrot juice with *L. bulgaricus* and inulin

By *Filomena Nazzaro*, Florinda Fratianni, Institute of Food Science and Technology-CNR, Avellino, Italy*
*e-mail: mena@isa.cnr.it

Probiotics have a long history of use by humans

Dr. Metchnikoff is considered to be the inventor of probiotics. Interested by the longevity of the Caucasian population and its frequent consumption of fermented milks, he (1) proposed that the acid-producing organisms in fermented dairy products could prevent "fouling" in the large intestine and thus lead to a prolongation of life span of the consumer. According to the most recent definition, they are "live microorganisms that, administered in adequate amounts, confer health benefits to the host"(2). Probiotic microorganisms are clinically demonstrated to procure many benefits, such as the enhancement of the allergic conditions, or the irritable bowel syndrome, as well as the improvement of immune function; in

addition, many have also been proven promising candidates during the treatment of cancer (3). The probiotic bacteria used in commercial products today are mainly members of the genera *Lactobacillus, Bifidobacterium and Streptococcus (*Table 1*)*. These genera are present mainly in fermented foods, which are well suited to promoting the positive health image of probiotics for several reasons: firstly, fermented foods already have a positive health image; in addition, consumers are familiar with the fact that fermented foods contain living microorganisms, and, secondly, probiotics used as starter organisms join the positive images of fermentation and probiotic cultures.

Increasing beneficial bacteria

Another important way to increase the number of beneficial bacteria in humans is through supplementation with prebiotics. Prebiotics are non-digestible dietary food ingredients that, on passing through to the colon benefit the host by selectively stimulating the growth and/or activity of one or a limited number of beneficial bacteria *in situ*. Diet is the main factor controlling the intestinal microflora, and thus it is possible to modulate the composition of the microflora through foods. A range of substrates of dietary origin or produced by the host are available for fermentation by the colonic microflora; the most frequently studied examples are the oligosaccharide inulin-type fructans and fructo-oligosaccharides (FOS), which escape absorption in the small intestine and are metabolised by certain colonic bacteria. At least 4g/day, but more preferably 3 g/day, of prebiotics are needed to significantly elevate probiotics in the human gut (4).

The positive effect of combining probiotic and prebiotic components is defined as "synbiotic". This combination might improve the survival of bacteria crossing the upper part of the gastrointestinal tract, thereby improving their effects in the large bowel. With the

apparent market success of pro- and prebiotic products, different questions about the nature and the definition of such terms, and their potential health effects are asked by consumers. Of noteworthy meaning is whether foods containing probiotics might supply added value compared with traditional fermented foods containing living microorganisms, and whether this value is maintained during manufacturing of the product and is provided during its entire shelf life. The most frequently manufactured foods containing probiotic lactic acid bacteria are based on milk and its derivatives. Several studies have characterised and validated the probiotic and synbiotic properties of milk and dairy products (5, 6). However, such products may be unsuitable for people with lactose intolerance. Other fermented products (e.g., raw sausages and sauerkraut) can serve as carriers of probiotic organisms, but few of them are already widely available on the market. In recent years, consumer demand for synbiotic products has increased, and probiotics as well as prebiotic components are incorporated into drinks and marketed as supplements in the form of capsules, tablets, and freeze-dried products. Beverages such as fruit or vegetable juices may represent an ideal delivery medium for the supplementation of such health-promoting components.

Fruits, vegetables and their juices

Fruits and vegetables are rich in functional components such as vitamins and antioxidants. In addition, they do not contain dairy allergens that might prevent consumption by dairy-intolerant consumers. For these reasons, fruit and vegetable juices should be examined for their ability to support probiotic and prebiotic delivery in humans. Recently, the use of vegetable materials for the production of dietary beneficial drinks has increased in the food and health industry (7). Fruit and vegetable juices could serve as a good medium for functional ingredients such as probiotics and prebiotics

(8,9). These products are recognised as healthy foods and can be consumed frequently by a significant percentage of consumers.

Not all lactic acid bacteria can survive in vegetable or fruit juices. Therefore, obtaining a fermented juice from these sources requires the use of specially selected cultures to ensure proper progress of the fermentation process and a guaranteed consistent products with beneficial organoleptic features. The investigation of vegetable juices with synbiotic properties is followed with growing interest by the food industry, which has high expectations for food products that meet the consumer demand for a healthy lifestyle.

Carrot juice as a basis for a synbiotic beverage

Carrot juice is one of most promising products as a basis for manufacturing a synbiotic beverage. The juice can be "synbioticed" by fermentation with a probiotic microorganism, such as *Lactobacillus delbrueckii* subsp *bulgaricus,* and to which inulin is added as a prebiotic component.

In our trials*, L. bulgaricus* was found capable of rapidly utilizing carrot juice for cell synthesis without nutrient supplementation or pH adjustment. This result is in agreement with other studies (9,10), which suggested that different vegetable juices could serve as good media for growing probiotics by stimulating their growth and resulting in high viable counts; indeed, the decrease in pH observed after 48 hours fermentation, permits hypothesising about the forceful fermentative action of the microorganism. Several factors may affect the survival of lactic acid bacteria: strain, inoculation level, incubation temperature, pH, growth promoters and inhibitors, presence of oxygen and hydrogen peroxide, concentration of metabolites, buffering capacity of the media, storage temperature, and availability of nutrients. To exert beneficial effects in the host, it is essential that lactic acid bacteria

be alive and abundant in the product at time of consumption. No general agreement has been reached regarding the concentration of probiotics necessary to achieve beneficial effects; counts from 10^6 to 10^8 CFU mL–1 are usually recommended. In our study, *L. bulgaricus* was capable of surviving at low pH in the fermented carrot juice after 1 month storage at 4°C. This showed a discrete number of viable cells which were still sufficient (quantitatively) to positively affect host health (Table 2). This effect has been previously demonstrated for other lactic acid bacteria, for which survival under analogous conditions might be enhanced by the presence of the carbohydrates present in vegetable products (11). After 4 weeks storage at 4°C, the amount of the micro organism present was still sufficient to give "probiotic" characteristics to the juice. Furthermore, the pro- and prebiotic components in carrot juice and the fermentative process did not noticeably decrease the content of ß-carotene present in the vegetal matrix used as a substrate (Table 2). The values observed in such products are proportional to those present in the unfermented juice, at the end of storage. These results are in agreement with those previously reported for other vegetal juices fermented with either a single strain or a mixture of other lactic acid bacteria (10, 12). Carrot juice fermented with *Lb. bulgaricus* and inulin might be a good source of probiotic *Lactobacilli* and also nutritional components even after 4 weeks storage at 4°C. In addition, it would be completely functional when ingested. On the whole, the results impact positively towards a broader utilization of carrot juice, i.e. suitable on the basis of a complex functional product with higher added value.

Table 1 : Main probiotic microorganisms

Bacteria

Lactobacillus*: acidophilus, amylovorous, brevis, casei, cellobiosus, crispatus, delbrueckii subsp.bulgaricus, fermentum, gasseri, johnsonii, paracasei, plantarum,reuteri, rhamnosus*

Bifidobacterium*: adolescens, animalis, bifidum, breve, infantis, longum,thermophilum*

Streptococcus: *thermophilus, lactis, cremoris, salivarius subsp. bulgaricus,intermedius*

Leuconostoc, Pediococcus, Propionibacterium

Bacillus: *cereus* var. *toyoi*

Yeasts and moulds

Saccharomyces: *cerevisiae, boulardii*

Aspergillus *: oryzae*

Table 2: Monitoring of pH and cell survival (expressed as CFU/ml) of L. *bulgaricus* grown in carrot juice plus inulin at time zero and after 4 weeks of storage at 4°C. Means and standard deviations (in parenthesis) for n=3.

	pH	CFU/ml	ß-carotene (mg/dl)
4 weeks	3.42 (+/-0.04)	$5.1\ 10^6$	5.30 (+/- 0.17)
Time 0	4.98 (+/-0.15)	$1.4\ 10^6$	5.06 (+/- 0.1)

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For further information contact: Filomena Nazzaro, Lab of Biotechnology and Food safety, Institute of Food Science and Technology-CNR, Via Roma 64, 83100, Avellino, Italy.
Tel + 39 0825 299102; Fax + 39 0825 781585; e-mail:mena@isa.cnr.it

Nutrigenomics: linking genomics, nutrition and health research

By Siân B. Astley, Institute of Food Research, Norwich Research Park, Colney, Norwich NR4, UK
e-mail: sian.astley@bbsrc.ac.uk

A patient with a family history of early death from heart attack comes to you to obtain a nutrition and lifestyle advice. As well as collecting family and diet histories, and making physical and blood biochemistry measurements, you also scan their electronic genome card. From this information, you develop a selection of targeted recommendations for diet and exercise, and drug regimens depending on their preferred lifestyle. Is this entertaining fiction or a frightening glance into the future? (Based on a scenario developed by Ruth Debusk et al., 2005).

Introduction

We eat a complex mixture of foods, which contain a host of different nutrients and other bioactive compounds. Intricate biochemical processes extract energy and other useful components, enabling us

to keep our bodies and minds functioning effectively. In the past, many food compounds were dismissed, having no obvious nutritional role. We now know they have a range of biological effects. For example, eating a diet rich in foods containing plant polyphenols (e.g. apples, onions etc.) reduces the risk of developing gastrointestinal tract cancers; consumption of cooked tomato sauces reduces a man's likelihood of developing prostate cancer; and a high folate intake reduces plasma homocysteine, which is an independent risk factor for cardiovascular disease (CVD) as well as preventing neural tube defects in the developing foetus. What is also obvious is that the benefits of some dietary choices are not the same for everyone.

Some of us have genetic diseases that have no association with diet (e.g. sickle cell disease). Other disorders may have specific dietary needs (e.g. cystic fibrosis) and some conditions are exacerbated by specific foods (e.g. coeliac and food allergy), but these are not caused by diet. Some people carry or acquire a high risk of disease (e.g. breast cancer), which may or may not be affected by diet. For the majority, however, simply keeping our weight down, not smoking, not consuming alcohol in excess, and taking regular exercise will be sufficient to keep our risk low. Nevertheless, as we get older, our bodies are less effective at avoiding disease: our immune systems are less able to detect and mount a defence; our DNA becomes more error prone; and our proteins are less functional. The resulting breakdown in cellular structure and function leads to those diseases we associate with old age (e.g. cancer, cardiovascular disease [CVD], type II diabetes, cataract and macula degeneration, and arthritis). Poor diet can accelerate this degeneration whilst the majority of studies support that a diet rich in fruits and vegetables, cereals and plant oils reduces the risks. Thus, it is clear that diet and risk of disease are intimately

associated not only in terms of excess but also in promoting optimal health. Understanding this relationship, however, has proven very difficult.

Studies of diet-gene interactions have been underway for a number of years but researchers have been limited to a handful of pre-selected genes, one or two biochemical pathways, and individual or simple groups of compounds. The human genome project has provided new tools (so-called post-genomic technologies) and information about our genetic code (genome) that allow a more holistic perspective.

The European Nutrigenomics Organisation

In 2004, twenty-two organisations from across 10 European countries formed The European Nutrigenomics Organisation (NuGO). This EU-funded Network of Excellence is creating a European virtual centre of excellence in nutrigenomics. With two new partners and six world-wide collaborating centres, they are developing the post-genomic technologies and our understanding of nutrigenomics. NuGO is also facilitating the application of these technologies in European nutrition research and training a new generation of European scientists in their use. For the first time EU-funding has been provided to support the integration of resources and the expertise needed to strengthen scientific and technological excellence. The complexity of food and the human body means it is no longer possible for individual nutritionists to work in isolation. Instead, within NuGO, you will find molecular biologists, mathematicians and computer programmers working with cell biologists and food chemists. Integration of such specialists can be difficult. Trying to assimilate activities across Europe simply adds the additional dimensions of language, timescale and culture. But, the integration of their organisations and their respective infra-

structures introduces new problems; these organisations usually compete for funding and the best researchers.

The molecular terminology

Cells are the fundamental working units of every living system. The instructions needed to undertake all cellular processes are contained within two metres of carefully folded DNA (deoxyribonucleic acid), which is made up from two strands running in opposite directions twisted together to form the double helical structure described by Crick and Watson. The strands are fashioned from nucleotides – complex chemical structures consisting of a phosphate, a sugar and one of four bases guanine [G], thymine [T], adenosine [A] and cytosine [C]), which are fixed together via the phosphate. The progression of the four bases along these strands spell out our common and unique traits (DNA code or blueprint). The complete sequence – just over 3 billion items of code – is the genome. It is changes in the DNA code, missing or extra copies, breaks and errors in joins and single-base differences that create the subtle difference between each of us and, in some cases, cause genetic diseases.

Regions within each chromosome, called genes, are the basic physical and functional units of heredity, and the human genome contains around 26,845 genes. This accounts for 1-2% of the entire sequence. A further 1-2% controls how and when these genes work; the role of the remaining DNA sequence is unclear. The study of the entire DNA nucleotide sequence, including genes, regulatory sequences, and non-coding DNA is called genomics. Structural genomics examines the physical construction of the DNA, and functional genomics how each gene functions/responds to given stimuli. Although DNA gets a lot attention, proteins are responsible

for cellular structure, growth and reproduction as well as the coordination of actions and responses that make up life.

The production of proteins from DNA is not a simple process. An edited copy of the DNA sequence for a gene is first created in ribonucleic acid (RNA), which is structurally very similar to DNA. Making this edited copy is called transcription. A gene that is actively involved in transcription is said to be expressed, but different genes are expressed to a greater or lesser extent. The complete set of RNA products that can be produced from a genome is called the transcriptome; transcriptomics is the study of the transcriptome.

The code held within RNA transcripts is subsequently used to produce protein in a process termed translation. Proteins are complex molecules made up from strings of twenty distinct amino acids. The chemical composition of amino acids causes them to attract or repel one another and in doing so create unique three-dimensional structures essential to correct functioning of the protein. The full complement of proteins produced is called the proteome. Subsets of proteins from the proteome will be produced by different cells and these will change in response to internal (e.g. eating) and external stimuli (e.g. cold). The study of the regulation of these processes is termed proteomics. Finally, metabolomics (or metabonomics) examines the pattern and response of our metabolites, which collectively form our metabolism.

Nutritional genomics or nutrigenomics

Given sufficient food, it is important that the right amount of each food component is absorbed, stored in an appropriate place and is available for use at the proper time. The key to understanding this, and its links to human health, is to observe how our bodies respond

to what we eat and how they make the most of what is available. Nutrigenomics is the science that examines gene expression, protein translation, and metabolic change in response to foods/food compounds using post-genomic and related technologies. The long-term aim of nutrigenomics is to understand how the whole body responds to real foods using an integrated approach termed 'systems biology'. The huge advantage in this approach is that the studies can examine people (i.e. populations, sub-populations – based on genes or disease – and individuals), food, life-stage and life-style without preconceived ideas.

The wealth of data generated by a system biology approach creates its own problems. For example, a single analytical procedure on one sample from an individual using only one technique may generate in excess of 30,000 data points, which may or may not be inter-dependent. Storage and interpretation of the massive amounts of data generated has fashioned bioinformatics (study of the inherent structure of biological information and biological systems), which brings together the analytical theory with the practical tools of mathematics and computer science. Our understanding of the relationships within and between genes, proteins and metabolites is very limited, which means the post-genomics technologies are not a one-stop-solution, and results need to be confirmed with more traditional methods of analysis. Nutrigenomics also generates other problems, which are not so easily resolved.

The small changes in our DNA sequence that make us unique may ultimately have no impact on our health but they might also increase our risk of disease and may or may not respond to dietary and lifestyle changes. Chronic diseases such as cancer, CVD etc. involve many different genes; their interaction with one another and with an individual's environment (i.e. diet, exercise, smoking etc.)

appears to be equally as important, in terms of disease risk, as genotype and diet alone. What-is-more unlike genetic diseases (e.g. cystic fibrosis), which an individual either has or does not have, chronic age-related disease are hedged in relative not absolute risk. In other words an individual may be at higher risk but this does not mean they will become ill nor does it offer any guarantee to those not possessing a given genotype that they will avoid ill health in old age. In the future, we may understand the implications of subtle differences in the genetic code etc. but we need to consider what we do with this information now, and the responsibility lies as much with society as it does with the individual scientists in NuGO.

Conclusions

In the end, humans, their food, and their illnesses are complex. Food may affect our health via interaction with our DNA, up/down regulation of genes, post-translational modification of proteins, or metabolic perturbation. An individual's genetic profile may determine the extent to which food can favour health maintenance over disease development as well as establishing his/her risk of diseases in the first place. The complex emotional as well as biochemical relationship we have with what we eat and our health makes personalised (i.e. populations, sub-populations based on markers) – as well as individualised – nutrition fiendishly difficult. Although it still seems impossibly complicated, nutrigenomics and systems biology are the ideal, and perhaps, only tools able to answer the question – what should I be eating? What we do with the information is, however, another thing.

Institute of Food Research is a member of The European Nutrigenomics Organisation (NuGO): linking genomics, nutrition and health research (CT-2004-505944).

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More information from NuGO website at www.nugo.org or from Siân B. Astley, Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA Tel. +44 (0)1603 255219, fax. +44 (0)1603 255168, email sian.astley@bbsrc.ac.uk

Functional foods – a dietician's perspective

By Paula Mee, Nutrition Consulting, Dublin, Ireland
Contact: http://www.paulamee.com/paulamee/Main/Home.htm

There seems to be some consensus on the definition of the term "Functional Food", but no legal definition. The loose definition of a 'functional food' is any fresh or processed food that claims to have a health promoting and/or disease preventing property.

Functional foods and nutraceuticals

In the food industry, functional foods are sometimes called nutraceuticals, a combination of the words nutrition and pharmaceutical. In the consumer world, shoppers may consider 'functional foods' as an umbrella term for foods that have been genetically modified, processed foods that have been fortified with health promoting additives (for example, breakfast cereal fortified with vitamins and minerals), or foods that are labelled with specific health claims (for example, can help to lower blood cholesterol). In Ireland the best known functional foods are probably fermented dairy foods with live cultures and probiotic benefits.

But functional foods do not necessarily have added ingredients that give them their health promoting properties. The term can refer to certain foods that are naturally functional too, such as porridge oats, which contain beta-glucan soluble fibre which has been proven to lower cholesterol levels.

Ten years ago, a fortified breakfast cereal was just that, and consumers did not question the purpose of the added vitamins and minerals. However, a growing public understanding of the relationship between diet and disease, and the spiralling trend for health and wellness, has driven the demand for functional foods and fuelled their popularity. Many of us simply can't or don't want to give up our fast paced way of life and functional foods are positioning themselves to allow us to cope better with the stresses and strains of our hectic 24/7 lifestyles.

According to research conducted by Mintel, more than half of new food product launches are enriched with health promoting ingredients. Whether they do what they say on the package, however, is another matter.

Let's look at probiotic foods as an example. These claim to act by restoring the balance of microflora in the digestive tract. Many of the dairy-based functional foods contain lactobacillus and bifidobacterium bacteria, which are naturally present in the gut and aid digestion. The theory is that eating these functional foods will top up the good bacteria and keep bad bacteria at bay.

In practice, it doesn't always work like this. A recent study carried out on some probiotic products for the Food Standards Agency in the UK found that some of the added bacteria did not survive the

digestive system, and therefore did not reach the gut where they were supposed to help. This expose caused many shoppers to question why these products were allowed to be sold with wellbeing and gut claims? Whilst there is now the health and nutrition claims legislation in place, many shoppers are unsure as to whether the legislation is being properly enforced, or whether clever marketing strategies are used to overcome the legislation.

Shopper's perspective

From the shoppers' perspective, the plethora of functional foods now available on the market can be overwhelming, and indeed confusing. It can be difficult for even the savviest consumer to read between the lines and know where the clever marketing ends and the grounded science begins. For others, functional foods are mistaken as a magic bullet to help them reduce their cholesterol or lower their blood pressure, without really understanding how they work, or the need to combine these products with a healthy lifestyle.

Many want to have our cake and eat it too – quite literally. And if that cake is promising to protect them from bone disease or osteoporosis, then who are they to question it? They don't really care about the amazing ingredient that will improve their health, or the mechanism by which it will work – they simply want to buy the product and see the benefit. They put their trust in the scientists, the food technologists, the marketers and the regulatory bodies to ensure that the research has been done and that these products deliver exactly what they promise on the pack.

As a dietician, I believe there is a large role for functional foods to play as part of our overall diet, but we need to ensure that they are based on real consumer needs, sound science and that they don't

over promise and under deliver. There is a plethora of health enhancing ingredients and food components out there which can be incorporated in new products to deliver real benefits. But it's important to minimise knee jerk reactions by Industry. The 'in' nutrients or ingredient often seem to be pursued by every food category, to be incorporated into every staple. It's far better to be discerning about 'the best fit' for the product in terms of additional functional ingredients that can be delivered safely, effectively and appropriately.

Distract from healthy eating messages?

Whilst I firmly believe feel that there is a growing and valuable role for functional foods in our diets, I am frequently concerned about the distraction that these products can also pose to basic healthy eating messages. Product claims can cause people to forget that one of the most important factors in reducing cholesterol is cutting down on their saturated fat intake. Functional foods are generally expensive and we have to eat a certain amount of them, on a regular and on-going basis to reap the benefits. They can never replace the full range of nutrients to be gained from eating a diet rich in fruit, vegetables and whole grains, nor can they overcome the detrimental effects of an unhealthy diet, lacking in fibre, essential fats and containing too much trans and saturated fats.

Educating the public

Collectively, scientists, the food industry, marketers, health professionals and regulatory bodies have a role in educating the general public on the evolving role of functional foods in optimising health and preventing disease. Legislation needs to be tightened and enforced for the ultimate protection of the consumer who may be consuming large quantities of functional ingredients from many

sources without any knowledge of possible adverse effects of over consumption.

Foods which are functional

In their most natural state, fruits and vegetables, oily fish, whole grains, olives, probiotic yoghurt, pulses, nuts and seeds, are in my mind, *the* premium functional foods. They have innate or inherent functionality and the more unprocessed they are in our diets, the more health benefits they offer.

As core components of a diet, they provide us with the right balance of essential and other fats, good quality protein, starches and natural sugars. The problem is that not many of us are content to forego indulging in the tantalizing and expanding variety of new foods on offer, in preference to sticking to this whole food menu and cooking from scratch. Who can blame us if we can 'have our cake and eat it too'?

Examples of functional foods

Soya: The cholesterol-reducing effect of soya is well-documented. However, you need to ingest a large amount per day and it is difficult to disguise the flavour and texture of soya. The inclusion of at least 25g of soya protein per day as part of a diet low in saturated fat can help reduce blood cholesterol.
Oats: There is significant agreement that oat consumption can help reduce total and LDL cholesterol, thereby reducing the risk of coronary heart disease.
Cranberries: Cranberries contain proanthocyanidins (PACs) that can prevent the adhesion of certain of bacteria, including *E. coli*, associated with urinary tract infections to the urinary tract wall. The beneficial North American species of cranberries could also be incorporated into dairy products e.g. with cheese or yoghurt, fats spreads and also meats.

When you extract some of these health enhancing ingredients from natural functional foods or synthesize them in a food laboratory, and then add them to a food that most of us like, the premise of health and indulgence becomes an attractive driver for consumer purchase.

Functional ingredients

Plant sterol/ stanols: The cholesterol-reducing properties of plant sterols and stanols are no longer confined to fat spreads but are now also found in a wide range of dairy foods e.g. yoghurt, cheese-type products and dairy drinks, and also in juice products.

Phytoestrogens: These are compounds in plant foods which, in the human body, are converted to compounds with oestrogen-like effects. An example is isoflavones found in soy products. Soy does not have a high level of consumption in Europe, so instead soy fractions can be added to other foodstuffs. There is some epidemiological evidence that isoflavones reduce the risk of osteoporosis, coronary heart disease and some cancers.

Probiotics: These are a live microbial feed supplement that beneficially affect the host by improving its intestinal microbial balance. Many strains of bacteria are used in a variety of food types, e.g. *L. caseii immunitass, Lactobacillus acidophilus, Bifidus essensis, Lactobacillus rhamnosus GG*. They can aid digestion and help the immune system.

Inulin and oligosaccarides: These are non-digestible dietary fibres used to promote the growth of beneficial bifidobacteria in the colon – they act as prebiotics. These are often combined with probiotics (beneficial bacteria) to give an added benefit. Inulin can be added to spreads, yoghurts, processed cheeses, dairy drinks and meat products.

Omega-3 fatty acids: Fish oils, especially the omega-3 fatty acids EPA and DHA, have been shown to be beneficial to heart health and

influence a wide range of functions in the body including blood pressure. They have also been shown to relieve symptoms of rheumatoid arthritis.

The bioavailability of microencapsulated omega-3 fatty acids incorporated into foods has been shown to compare favourably with that of equal amounts of fish oil. Therefore, fish oils can be combined with a wide range of foods without affecting the flavour profile of the food and at the same time provide an added nutritional benefit.

Folic acid: Women of child-bearing age are advised to take a daily supplement containing 400μg of folic acid to help prevent neural tube defects which affect one in every 1000 births in Ireland. Natural folate is often damaged by processing and cooking and less readily absorbed by the body. Therefore, supplements and fortified foods are more effective. The mandatory fortification of flour with folic acid will now be pursued by the Irish Government. However, care must be taken as high intakes of folic acid may mask anaemia which is an early symptom of vitamin B12 deficiency in older people.

Milk-derived tripeptides (lactotripeptides): Bioactive peptides are generated when *Lactobacillus helveticus* decomposes milk casein. Unilever launched a Pro-activ blood pressure lowering drink in conjunction with Calpis (Japan).

Lactoferrin: Whey contains many bioactive peptides, one of which is Lactoferrin. This peptide plays an important role in the immune response, protecting the body from infection. It is also a bioavailable source of iron. Functional food products with Lactoferrin are available in Japan and Taiwan.

Lutein and zeaxanthin: These are the only carotenoids present in the eye lens and are thought to have a role in decreasing the risk of cataract extraction. They can be used in a wide range of dairy

products but introduce colour to the product and so may be more suited to yoghurts and drinks than to spreads.

Lycopene: It may decrease the risk of the development of prostate and other cancer. It has a red colour, and so is suitable for products such as coloured dairy beverages, yoghurts or ready-meal applications.

Conjugated linoleic acid: This is a natural product of digestion in ruminant animals and can, therefore, be found in beef and dairy products. It has many isomers. Some have anti-carcinogenic and anti-inflammatory effects while others are thought to reduce the amount of fat store after eating and hence may lead to weight reduction.

Selenium: This is found in many foods but the level in plant foods depends on the content and availability of the element in the soil where they are grown, but it is generally low in Europe. It is a powerful antioxidant and free radical scavenger. The FDA allows a claim that selenium may reduce the risk of some cancers.

Unconvincing

There are many more 'functional food ingredients' in products on the worldwide marketplace. Many of these make weak generic claims that really have no scientific basis. Alternatively, the level of the functional ingredient may be too low to have a beneficial effect.

Aloe vera: This has been known for centuries as a soothing and moisturizing tonic for the skin. Now we are seeing Aloe vera incorporated into food products which claim to achieve beauty from the inside.

Collagen and ceramide: Lots of products are currently being launched in Japan which contain collagen and ceramide. These ingredients claim to moisturise and strengthen the skin against ageing.

Ginseng: This has been used for thousands of years in Asia as a tonic to improve mental and physical vitality. As a result, it is a commonly found ingredient in energy products. However, human studies have failed to show convincing evidence of its beneficial effects.

Guarana: It contains a high amount of guaranine, a chemical substance with the same characteristics of caffeine. It, therefore, has stimulant properties and is found in products which are marketed as energy-giving.

Note: Currently in Europe, if a food ingredient has not been used for human consumption to a significant degree within the Community before 15th May 1997, it must be authorised under the EC Novel Food Regulation 258/97. The ingredient must undergo a safety assessment before it is allowed onto the market place.

Paula Mee, Nutrition Consulting is from Galway, Ireland. Paula graduated from University College Galway with a BSc in Biochemistry. She then completed postgraduate qualifications in Dietetics and a Masters in Health Science in Leeds Metropolitan University and has recently been awarded a Diploma in Allergy from Southampton University. She has also completed the British Dietetic Association's Sports Dietician course. Nutrition Consulting was set up in 2004 and offers organisations and industry an extensive range of services in nutrition, product development, and marketing communications. Prior to this, Paula was the Nutrition Manager for the Superquinn supermarket chain in Ireland. Previously she worked as senior nutritionist in the Irish National Dairy Council.

Functional Foods--Moving into the Mainstream?

By Fiona Angus, Business Manager—Nutrition, Consumer & Sensory Science, Leatherhead Food International, Randalls Road, Leatherhead, Surrey KT 22 7RY, UK
e-mail: FAngus@LeatherheadFood.com

In the past, contamination of foods was a major health problem. Currently non-communicable diseases are the largest diet-related public health problem. It has been estimated that, cancer and coronary heart disease currently account for 60% of deaths and around a third are related to diet. Prevalence of obesity has trebled since the 1980s and a quarter of the population are obese and half are overweight.There have, therefore, been significant efforts over the last 20 years to improve diet and never before has there been so much focus on healthy eating. In the same period, we have seen the emergence of functional foods, defined as foods that have health benefits over and above their inherent nutritional value. Originating in Japan, the most successful functional foods are primarily focused on addressing major health issues like high cholesterol and poor immune, gut and bone health and these represent dominant sectors in the global market estimated at $16.1bn. The UK market accounts for around a 10% share. Gut health products dominate globally with a sector worth $6.8bn, heart health products account for $5.8bn and immune function products $2.6bn. The market is developing, however, and an increasing range of innovative products is being developed to address more specific health conditions and also to provide new products to meet changing lifestyle needs. The weight control sector for example is only quantifiable in Japan but with evidence of product activity in other countries means that this is certainly set to change.

Heart health and cholesterol

Heart health products are important in Europe, reflecting concerns over the high levels of death and illness caused by the disease. The heart health category has been driven by innovations in a number of key ingredient application areas including phytosterols and stanols, omega-3 fatty acids, soya, and dietary fibre. Cholesterol spreads were mainstay of the heart health sector of the functional foods market and have been around since around 1990, first appearing in the United States. Most recent developments have been the extension of the phytosterols and stanols into a variety of product types including yoghurts, juices and even breads. In addition, an important launch in Europe was Danacol from Danone in 2004, a probiotic and cholesterol lowering drink in dose delivery format. Increasingly, soya based products are being positioned on a cholesterol lowering platform too and a wide range of products from dairy products to soft drinks and cereal products are being fortified with omega-3 fatty acids. There is also a high level of interest in oat and barley beta glucans for cholesterol reduction and a number of breakfast cereal manufacturers have recently introduced new oat based variants of their cereal , for example Optivita from Kelloggs and Oatibix from Weetabix, both launched in 2006 in the UK. Future developments in the heart health sector are likely to extend to blood pressure reduction. Nearly 1 billion people worldwide have high blood pressure, with 16 million affected in the UK. Unilever launched a product under the Flora Practiv brand in the UK in 2005 but it was withdrawn in 2006. In 2007, Danone, however, introduced Danaten a blood pressure lowering drink in dose delivery format in Spain. There is also renewed interest in the area of antioxidants with chocolate companies focusing on the antioxidant levels in chocolate. For example, Hershey's Natural Flavanol Antioxidant Milk Chocolate in the United States and juice companies introducing Acai and pomegranate products boasting

high levels of antioxidants and heart health benefits, like Pomegreat from RJA Foods which has been around since about 2003.

Functional products for gut health

The major emphasis in gut health products has been on probiotics, prebiotics and dietary fibre. Probiotics are live beneficial bacteria and prebiotics are ingredients, which boost the natural levels of beneficial bacteria in the gut. Probiotic dairy products have led product development, firstly in terms of probiotic yoghurts and then via dose delivery probiotic drinks, which now represent the fastest growing sector in the market. Probiotics and prebiotics are being used increasingly outside the dairy sector with significant innovation in terms of application in a broad range of products including bakery and cereal products and soft drinks. One example includes Vive from Kashi launched in the US in 2007, a breakfast cereal claimed to be the first shelf stable probiotic food in the United States.

Bone health

Despite considerable product activity, the global market for bone benefit foods remains small and fragmented. Calcium enrichment has been the most popular route for product development to date and improvements in technology have meant that calcium can be more easily added to a broader range of products including soft drinks. There is also increasing interest in the application of other minerals, such as magnesium, as well as prebiotics and ingredients such as soya in bone health products.

Obesity and diabetes

Spiralling levels of obesity and diabetes are stimulating demand for foods that might reverse the trend. Here we are not just talking about foods with lower calorie content but those with added ingredients that help suppress appetite in particular. Fabuless™

from DSM containing oat and palm oil has been used in a number of dairy launches in 2007 including AdagioVersus from Lactogal in Portugal and Optiwell Control in Germany from Campina. High levels of protein and fibre are also being used to position products in this sector.

Functional products for anti-ageing

Another emerging area is anti-ageing. The drive for people to stay looking younger for longer has prompted moves from some food companies into the beauty area and visa versa. For example, Olay have introduced a vitamin range two years ago, and beauty foods are starting to emerge on the mainstream market. Essensis from Danone launched in 2007 in some European countries, is a yoghurt product containing ProNutris aimed at improving the skin. There is also a drive to produce functional food products for the over 50s and despite difficult marketing issues a number of companies are launching products aimed at this population group. Jour Après Jour Partenaire Jeunesse milk from Lactel in France, an anti-aging milk with added selenium, zinc and vitamin E for skin health and vitamin D, A, magnesium and fibre is a good example.

Foods to combat stress

Stress is also a major concern and in the food area, there has been considerable development of the green tea market with positioning on clear de-stress platforms. A number of milk producers have introduced night time milks to aid sleep, many of them are based on cows' milk which is high in serotonin. Product examples include Night Time Milk in the UK and Dreamerz milk in the United States.

Tailored nutrition

There is also an increasing focus on tailored nutrition, for example, nutritionally enhanced products to meet individual needs. A range of products is available in the United States and are now starting to

appear in Europe. Women are a key target market and recent examples include Luna Sunrise, fortified bars aimed at women from Luna USA and Bloom, a soft drink for women from Del Monte US.

The future

Growing consumer acceptance of the link between diet and health and an increasing consumer responsibility for their own health are likely to be key drivers in the functional foods market of the future. Diet-related diseases remain a cause of premature death in the western world and a major burden on overstretched resources. Improving diet is, therefore, an opportunity for western governments to reduce spiralling healthcare costs. The ageing population and a desire to remain healthy into old age should also boost consumer interest in these products. Currently the market is predicted to outperform the food and drinks market as a whole as these foods become everyday shopping basket items for members of the increasingly health conscious population.

Inherent functionality:--a useful term for consumer information ?

By Ronan Gormley, Ashtown Food Research Centre (Teagasc), Dublin 15, Ireland
e-mail: ronan.gormley@teagasc.ie

Functional foods are broadly defined as those that offer 'something extra' in terms of health benefits than the basic food item, e.g. probiotic-enriched yoghurt versus ordinary yoghurt. The term functional food, by its very nature, tends to suggest that other foods are not functional and have less health benefit relative to functional foods. This is far from fact as many animal and plant foods are highly beneficial for health 'as consumed' and possess inherent functionality. The term *inherent functionality* is stronger than the term *naturally present* used to describe health-promoting constituents occurring naturally in foods such as conjugated linoleic acid (CLA) in dairy or meat products. The author suggests, therefore, that *inherent functionality* is a term needed for consumer information in that foods of the same type may differ in their inherent functionality and scientists/technologists/consumers should be aware of this. This can be demonstrated using many examples such as taurine in fish, antioxidants and dietary fibre in fruit and vegetables, antioxidants in olive oil, CLA in animal products, and phytosterols in grains; some of these are discussed below. These naturally-present substances are in addition to the traditional nutrients, i.e. carbohydrates, proteins, fats, vitamins and minerals.

Taurine in fish

A number of recent medical studies have shown that taurine (*circa* 1.5g/day) is beneficial for cardiovascular health and helps to restore suppleness of human arteries [Fennessy *et al., Circulation*, 2003,

107 (3): 410-415]. Fish is a good taurine source and tests for taurine content were conducted recently at Ashtown Food Research Centre, Dublin. The content in four species purchased in supermarkets (eight test dates) was in the order plaice (126), cod (93), mackerel (69) and farmed salmon (53mg/100g wet weight). Values for spot samples of a number of other species were albacore tuna (155), ray wing (128), wild salmon (53), siki shark (44), whiting (35), Greenland halibut (28), roundnose grenadier (6) and Baird's smoothhead (5mg/100g wet weight). These data indicate that fish species have different levels of *inherent functionality* (in terms of taurine status) with albacore tuna having the highest level.

Dietary fibre in apples

The alcohol insoluble solids (AIS) (largely dietary fibre) fraction in apples is beneficial in controlling late maturity diabetes and level of dietary lipids [Mayne *et al., Irish Journal of Medical Science*, 1982, **151 (2):** 36-41]. Tests have shown that Golden Delicious apples (3.64%) are more *inherently functional* than Red Jonathan (3.28%) or Cox's Orange Pippin (2.89%) in terms of AIS content (Gormley, *Journal of the Science of Food & Agriculture*, 1981, **32:** 392-398) and hence their likely effect on diabetic control. This study followed an earlier one with 76 human volunteers which showed that eating two Golden Delicious apples per day significantly reduced serum cholesterol levels and raised the high density lipoprotein fraction (HDL) thus demonstrating efficacy and the *inherent functionality* of apples in terms of cholesterol reduction (Gormley *et.al., Irish Journal of Food Science & Technology*, **1**: 117-128).

Antioxidants in olive oil

Olive oil is a key contributor to the health-giving attributes associated with the Mediterranean diet, since the health-related properties (e.g. contributing to the prevention of thrombosis-related

diseases) of olive oil are 'added' to those foods (e.g. vegetables and fish) which are served with olive oil [Serra, *Pathophysiology of Haemostasis & Thrombosis*, 2003, **33(5-6):** 461-465]. The *inherent functionality* of olive oil varies considerably depending on variety, cultural practices, and on extraction and processing procedures. For example, extra virgin olive oil would be expected to be more *inherently functional* than virgin olive oil than non-virgin oil. The most abundant antioxidants in virgin olive oil are hydrophilic phenols; however, tocophenols and carotenes also contribute to antioxidant capacity. The influence of olive variety has been demonstrated by Servili and Montedoro (*European Journal of Lipid Science & Technology*, 2002, **104:** 602-613) who showed secoiridoid (the dialdehydic form of eienolic acid linked to 3,4-dihydroxyphenylethanol) contents of 558, 61 and 68 mg/kg in the varieties Moraiolo, Frantoio and Leccion, respectively. The negative effect of fruit ripening on the phenolic content of virgin olive oil has also been demonstrated with lowest hydrophilic phenolic conents in over-ripened olives.

CLA in ruminant animal products

Meat and dairy products are *inherently functional* foods via their content of conjugated linoleic acid (CLA), bioactive peptides and other agents. CLA has gained considerable attention in recent years because of its many beneficial effects on human health including anti-carcinogenic and anti-atherogenic activity, and its ability to reduce the catabolic effects of immune stimulation (O'Shea *et al., Trends in Food Science & Technology*, 1998, **9:** 192-196). A number of factors influence the *inherent functionality* of meat and dairy products via their effect on CLA content. For example, the CLA content of bovine milk is influenced by lactation number, feed allowance, dietary oils and by seasonal effects. The effects of pasture (grass) are particularly noteworthy. Cows on pasture

produced milk fat with higher CLA contents than animals receiving only one third or two thirds of their daily feed from pasture [Dhiman *et al., Journal of Dairy Science*, 1996, **79** (Suppl. 1): 137 Abst.]. For grazing steers, French *et al.* (*Journal of Animal Science*, 2000, **78**: 2849-2855) demonstrated increasing CLA levels (5.4, 6.6, 10.8 mg CLA/g fatty acid methyl ester) with increasing intakes of grass compared with 3.7mg/g in animals fed concentrates.

Natural complexity

Natural complexity presupposes that 'nature does things best' and that nutrients in foods as eaten are different than if taken in pill or capsule form. For example, it can be argued/proposed that vitamin C in an orange is hydrogen bonded and as such may be more available than that in a tablet. Gormley *et al.* [Food, Health and the Consumer, Elsevier Applied Science, 1987, pages 71-72 (ISBN 1-85166-108-5)] proposed that whole foods should preferably be eaten whole for at least two reasons, (i) key nutrients are retained, and (ii) nutrients are 'diluted'. This proposal favours *inherently functional* foods over conventional (i.e. man made) functional foods in that the concentration of the key compound/agent in the latter may be too high, and there is also the possibility that the key compound/agent may also be obtained from other functional foods thereby leading to an intake overload.

Retaining inherent functionality

Many studies have been conducted on losses of the major nutrients, vitamins and minerals in foods during storage and processing. However, there are relatively few studies on losses of *inherent functionality* and most of these are fairly recent. This is a particularly important field of study especially in products such as prepared salads that are held in chill storage for a number of days,

and while appearing fresh may have lost *inherent functionality*, especially in terms of antioxidant compounds.

Conclusion

The term *inherent functionality* is useful for the description of foods that have 'naturally present' constituents that are protective of, or conducive to, good human health.

The Bakery: a potential leader in functional food applications

By Anton J. Alldrick, Campden & Chorleywood Food Research Association, Chipping Campden, United Kingdom, GL55 6LD
e-mail: a.alldrick@campden.co.uk

It can be argued that the term, 'Functional Food', embraces not only foods which confer an additional physiological benefit over and above being simply nutritious but also those foods which have been reformulated to provide essential nutrients which might not otherwise be consumed in sufficient quantities. Bakery products are an ideal matrix by which functionality (whatever its form) can be delivered to the consumer in an acceptable food. Ranging from bread through to biscuits, cakes and pastries; bakery products play a pivotal role in the European diet. Bread is arguably one of the oldest functional foods in existence, as Hippocrates observed:

> *"To the human body it makes a great difference whether the bread be made of fine flour or coarse; whether of wheat with the bran or without the bran (1)"*

Hippocrates' observation related to the effects of dietary fibre. Applying the broad definition of functional foods used at the beginning of this article, products made from UK mandatorily fortified white flour might be considered to be functional with regard to other nutrients not normally associated with farinaceous products. Under current UK legislation (2), in order to compensate for the loss of those micronutrients accompanying the removal of the bran and germ during milling, white flour is fortified with the vitamins thiamin and nicotinic acid as well as the mineral iron. However, the same regulations also require supplementation of white flour with calcium carbonate. Supplementation results in levels of calcium within white bread-making flour some 3-fold greater than in wholemeal. Within the UK therefore, cereal-based foods provide somewhere in the region of 30% of the nation's dietary calcium. White bread alone acts as the source of 13% of the total calcium intake (3), most of which can be attributed to mandatory calcium carbonate supplementation of white flour. Given the contribution of calcium nutrition to bone-health and related diseases (e.g. osteoporosis), this cannot be considered to be an insignificant contribution to the Nation's health.

Bread as a carrier

Of all bakery products, bread probably provides the most ideal food to deliver functionality. Reference has already been made to bread being a source of calcium. In terms of other micronutrients, there is a momentum both in the United Kingdom and the Republic of Ireland for mandatory fortification of white flour with folic acid as part of a programme to reduce the incidence of babies being born with neural tube defects. Bread also provides a matrix in which to provide dietary fibre in a form acceptable to a large body of consumers. The respective merits of bread baked with white or wholemeal flours are a subject of continuing debate. Given that we

now live in a consumerist society, the fact remains that, in a number of western countries, bread made from white flour is the bread of choice; the reasons for this are many; but often relate to the organoleptic properties of products made from wholemeal flour [discussed by Alldrick, 2001 (4)]. A major challenge faced by food ingredients manufacturers has been to develop sources of purified dietary fibre which are not only physiologically effective but also do not compromise the quality attributes important to the consumer. The latter point is extremely important. Work with 'first generation' dietary fibre preparations identified a number of technological challenges including a need for increased amounts of water as well as doughs with reduced extensibility and consequent diminished product quality (5). These challenges have been largely overcome by the development of 'second generation' dietary fibre preparations. These materials are generally white, tasteless and have water absorbency characteristics designed for the product which they are intended to be incorporated into.

Dietary fibre sources

An example of the versatility of these materials can be seen from a small trial undertaken at CCFRA. This was part of an investigation as to the role of dietary fibre sources on the *in vitro* starch digestibility of white sandwich bread. In this experiment 5% of the flour was replaced with one of three dietary fibre preparations [oat bran, low dp (degree of polymerisation), inulin and high dp inulin] plus a compensatory amount of gluten – no other ingredients were changed. This resulted in increases in dietary fibre content from 2.0 for the control bread to 2.3% for the oat-bran supplemented bread and 4.25% for the inulin-supplemented breads. Consideration of Figure 1 shows that even with such a relatively simple substitution it is possible to produce a product acceptable to the consumer.

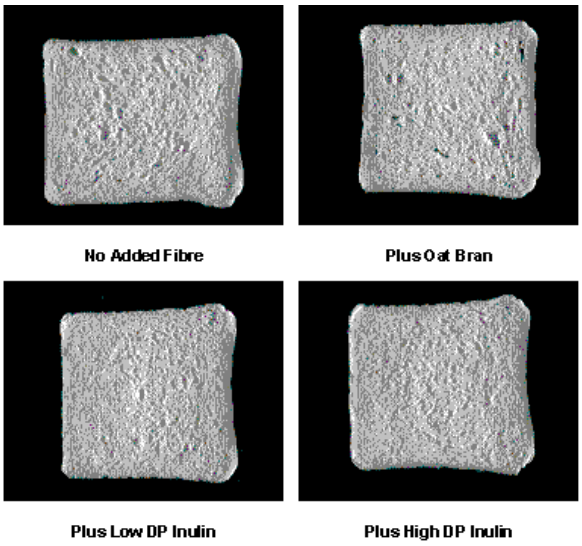


Figure 1: White sandwich bread baked with additional dietary fibre

Improved acceptability

In these cases, adding dietary fibre sometimes actually contributed to improved consumer acceptability. Adding fibre often resulted in a brighter and also (in the case of the high dp inulin containing bread) softer crumb. This work also highlighted the importance of the rheological properties of the dietary fibre with regard to certain physiological effects attributed to it. *In vitro* carbohydrate digestibility studies based on the method of Brighentii *et al.(6)* (Figure 2) performed on these breads demonstrated that the greatest reduction in digestibility, over that predicted due to substituting fibre and gluten for some of the flour in the recipe, was seen with product made using the oat bran preparation. This was probably due to its having a far higher degree of polymerisation than either of the two inulin preparations

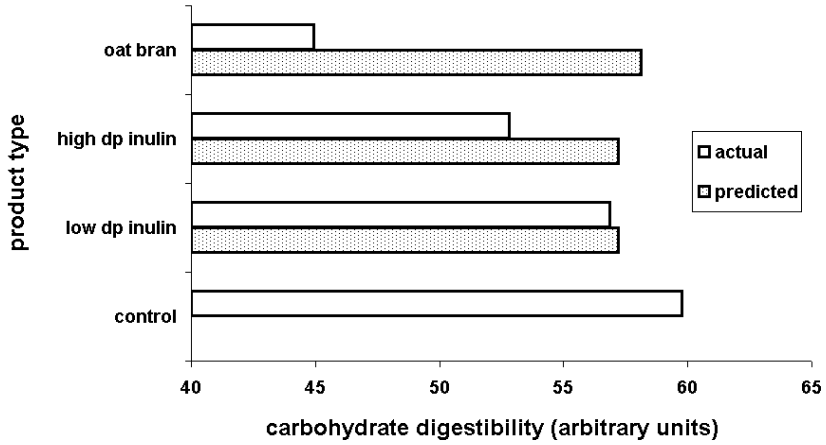


Figure 2: *In-vitro* carbohydrate digestibility of sandwich breads made with different purified fibre preparations

'White' fibres are enjoying widespread use within the bakery industry. For example, one major supermarket in the UK has reformulated its standard private label white bread to include a commercial resistant starch preparation which results in a product with a dietary-fibre content comparable to commercial wholemeal bread.

Marine oils, soya, linseed

Developments in processing and ingredient technology make bread an ideal consumer-acceptable food-matrix which can assist the consumer to take in optimal amounts of particular nutrients or compounds of known physiological benefit. An example of the former reflects the technological developments to deliver marine oils in a form which does not corrupt the desired organoleptic properties of the finished product. In the case of bread, improved oil refining techniques and the use of micro-encapsulation have led to a number of white-bread type products entering the market. These contain nutritionally significant quantities of long chain omega-3 fatty acids and do not have the off-flavours traditionally

associated with marine oils. In terms of functional ingredients conferring an additional physiological benefit, current commercial examples include bread products which contain soya and linseed. Originally developed in Australia as 'Sheila' bread, these products have relatively high levels of phyto-oestrogens and have been marketed by some as an aid to managing the symptoms of conditions such as the menopause.

Conclusions

Bread is arguably one of the oldest functional foods developed by man. It provides a matrix within which it is possible to optimise micronutrient consumption at a broad population level or to supply functional ingredients to particular groups. In developing functional bakery products (including bread), it is important to realise that achieving functional food quality does not simply involve delivering the active principle at the appropriate level for physiological effectiveness, but also supplying a product which meets the consumer's requirements in terms of appearance, taste and texture. This can only be achieved by a multi-disciplinary approach.

Anton Alldrick is Special Projects Manager within the Cereals and Cereal Processing Division at Campden & Chorleywood Food Research Association, the world's largest, independent, membership-based food research and development organisation.

Encapsulation:- an essential technology for functional food applications

By Denis Poncelet, ENITIAA, UMR CNRS 6144, 44322 Nantes cedex, France

e: mail: poncelet@enitiaa-nantes.fr

Since the last world war more than 60 years ago, we assisted in a revolution on the improvement of production methods leading to an abundance of food in our occidental countries unknown to mankind before. Our fridge is full! This abundance is also associated with a diversification of the foodstuffs. Some products formerly considered as "luxury" find their place in our quasi daily food (salmon, duck fillet …); fruits and vegetables reach us from all over the world.

The abundance has driven people to request more from the food they eat over and above energy supply; for example, to provide safety, health, and why not--- fun.

'Food mutation'

However, there is another equally important revolution in our society. From traditional and familial "cuisine", we have moved to industrial cooking, to consume as catering (fast food) or to bring back home. Recomposed powders, mixes, storage period extension, and the need for innovation have fundamentally modified the handling foodstuffs. It is simpler and less costly for industry to transport, store and rehydrate dried powders than to transport hydrated food products. Unfortunately, dehydratation often has negative effects on the texture, flavour and solubility of the rehydrated food. It is frequently necessary to supply food powders with their inherent aromas, vitamins, and other properties. In this context and application **microencapsulation** has become a highly

important tool for food process engineers. Protection during storage or processing, released at the right time and place (e.g. during cooking), the encapsulated additive will provide all its potential to the food.

Vitamin A

Vitamin is deficient in Asian foods and has to be supplied. The initial proposal was to incorporate vitamin A into glutamate, a taste enhancer used in these countries. However, Vitamin A is yellow and turns brown on oxidation while glutamate salt must be white to be appreciated by customers. Coating Place (USA) has developed a process for coating particles of vitamin A, colorizing them in white, while offering protection against oxygen, humidity and light.

Pro- and prebiotics

Traditional foods contain many different bacteria beneficial for health. However, the pasteurization and long-term storage leads to food with a reduced concentration of these bacteria. It was then proposed to supplement food with selected health-support bacteria, i.e. probiotics. However, the most efficient ones are generally fragile cells and need protection, for example, by microencapsulation. In the frame of a European project (MEPPHAC), we have demonstrated that coating probiotics can enhance their survival by a factor 20 during warm pellet extrusion. Microencapsulation allows the mixing of probiotics with materials promoting their growth and attachment in the intestine (i.e. prebiotics). It is then possible to develop optimum cocktails of probiotics and prebiotics in a single formulation called synbiotics.

Spices and herbs

Aromas, spices and herbs constitute the core of pleasure-linked cuisine and eating. However, they also represent the first natural

functional foods. They interact with the other food ingredients during storage, freezing, and pre-cooking resulting, sometimes, in off flavours and loss of health potential properties. Microencapsulation protects them during these stages while releasing them, for example, during cooking. Microencapsulation offers, therefore, a unique approach for maintaining optimum quality and nutritive status in a range of foodstuffs.

New properties and functions

Encapsulation is a performing tool that confers new properties to normal materials. Obtaining a stable functional ingredient is inadequate if it cannot be easily integrated in the food.

Many vitamins, plant extracts and unsaturated acids are hydrophobic and dispersing them in hydrophilic food powders is a real challenge. In addition to protecting them, microencapsulation allows their conversion to suitable and managable powders. Similary, by encapsulation, brown sugar can be converted to a free flowing powder, suspended with hydrophobic vitamins in juice, or dispersed in cocoa or in cold milk.

Unsaturated fatty acids are recognized as beneficial for health. However, they sometimes have an unpleasant taste, which can become unacceptable when they are oxidized. Encapsulation largely overcomes this problem by taste masking. Moreover, incorporating flavours in the coating helps to make the functional food pleasant to consume. This application is used extensively in pet food supply as animals will refuse off-flavored ingredients.

Functional food ingredients may be incorporated into food or may be consumed independently as pills or fine powder. This does not require a prescription from a doctor. However, consumers must be

advised to limit their daily dose. This can be assisted by coating particles with a colouring material thus differentiating the nutraceutics from a drug or a food.

Listeria represents a high risk in processed meat. We have developed an encapsulation system consisting in a core containing two substrates (glucose and thiocyanate), coated with two enzymes, and then protection polymers. In the dry form, the mix is stable for long periods, but on contact with moisture releases an end-product with high bacteriostatic properties against listeria.

Innovation tool

Encapsulation can also be used as a tool for innovation. For example, Orbitz (Canada) sells a drink containing a suspension of coloured capsules containing different aromas and/or some vitamins, thus making functional food consumption a 'fun experience'. Salvona (USA) has developed encapsulation technologies allowing sequential release of aromas and sensory ingredients in functional foods.

Finally, microencapsulation can be used as a biocatalyst immobilization system to process food in a safer and more efficient manner. For example, reduction of ripening time and increased shelf life of cheese by processing with an encapsulated enzyme.

The number of applications for microencapsulation technologies in foods, and especially functional food, is increasing. However, many challenges still remain. For example, incorporation of water sensitive ingredients in high moisture foods is not solved because most capsules impermeable to water are not soft and will be detected by consumers. In January 2008, BRG (see below) organized a workshop in Switzerland on flavour encapsulation. A

consensus between the one hundred participants was that 83% of applications relate to one single technology (spray drying) and so there is a need for innovation.

Developing encapsulated functional foods

The principle of most technologies of encapsulation is quite simple:

- Active ingredient is mixed within a polymer solution; dispersed as fine droplets (spraying, dripping, emulsification); droplets solidified by gelation; drying; cooling; coacervation …
- Or, when a solid powder, particles are mixed in a fluid bed or a pan; coating solution spray applied to them; solidify by drying or cooling.

However, several constraints make the development of the encapsulation process difficult. Firstly, encapsulation is an extra cost, which has to be minimized. This applies to materials used to build the capsules but also to equipment or processing conditions. We have computed that continuous coating processes reduce the running cost by a factor 3 in comparison to equivalent batch processes.

Materials used for encapsulation in the food domain are very limited (some polysaccharides, a few lipids…). In pharmaceutical industries, despite the strict rules to be respected for approval, they have access to many more materials. In food, the engineer has to play finely with the formulation to achieve adequate properties in the membrane of the coating.

Most functional ingredients are sensitive to water, oxygen, light and temperature. Materials must, therefore, offer barriers to water (hydrophilic) and oxygen. Careful temperature control during processing is a major requirement. Moving from the so-called

Wurster coating process to a spouted bed process reduces temperature gradients (15ºC) in the reactor, thus increasing probiotic survival by a factor two.

Developing an encapsulated product is, therefore, a challenge, requiring a multi-disciplinary and integrated approach. Many encapsulation technologies currently exist, but many of are still at the development stage. Finding the most suitable partners for such development and production is a hard task.

Finding support for developing encapsulated functional foods

Fortunately, the scientific and industrial community are organizing themselves in this regard. The Bioencapsulation Research Group (BRG) (http://bioencapsulation.net) is probably one of the largest non-profit associations on applied microencapsulation with 2000 members over 80 countries. It organizes conferences, industrial workshops and provides information through its web site and news.
The COST 865 programme/project is a European platform for exchanges between researchers and industrialists on developing collaborative projects in the microencapsulation area and for publishing thematic books on encapsulation.
(http://COST865.bioencapsulation.net)

High hydrostatic pressure technology – Bringing the deep sea to the table

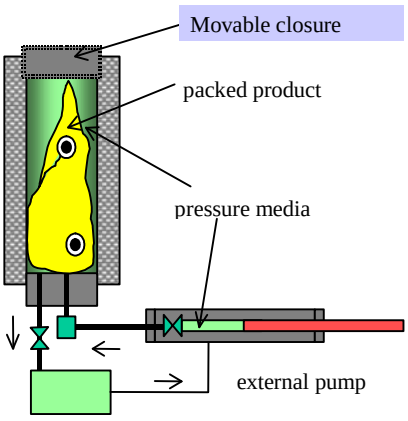
By Dietrich Knorr and Alexander Mathys, Department of Food Biotechnology and Food Process Engineering, Berlin University of Technology, D-14195 Berlin, Germany
e-mail: dietrich.knorr@tu-berlin.de

High hydrostatic pressure treatment of foods uses a pressure transferring liquid medium such as water exactly as we experience it in deep sea regions were pressures from all sides of up to 1100 bar (110 MPa) can be reached. Deep sea organisms are adapted to such pressures, and were and are subject to studies on pressure effects on biological systems. Modern, consumer driven, gentle and sustainable food processing concepts aim for low energy, waste free and consumer friendly technologies.

High hydrostatic pressure, which has firstly been applied to food systems more than 100 years ago [1] has experienced dramatic development work during the last 20 years and has been transformed from an emerging technology to a mature process with approx 120 industrial high pressure installations world wide processing about 120,000 tons of food annually.

Hydrostatic pressure may be generated by the addition of free energy, e.g., heating at constant volume or mechanical volume reduction. It is now technically feasible to reach pressures up to several gigapascals and to keep it constant for a comparably long time in specially designed vessels made from highly alloyed steel. A major task of high pressure applications in the food industry is the

Indirect pumping (batch)



Industrial high pressure equipment for the food industry. NC Hyperbaric (top): 2 x 300 L, max. 600 MPa (Tonello Samson, 2007, NC Hyperbaric, personal communication). Uhde HPT unit for sterilization (left): max. 700 MPa, T~121°C; Volume: 50 L (Uhde High Pressure Technologies GmbH). Principle of an external pressure intensifier (right) [3].

extension of shelf-life or the elimination of microbial pathogens since the viability of vegetative micro-organisms is affected by inducing structural changes at the cell membrane or by the

inactivation of enzyme systems which are responsible for the control of the metabolic actions. Thermodynamic properties and phase equilibrium of any system as well as transport properties such as viscosity, thermal conductivity, or diffusivity have to be considered in their functional relationship with temperature and pressure. Also, the equilibrium concentrations of chemical reactions are related to these quantities [2].

High Pressure (HP) at ambient temperature

Inactivation of vegetative micro organisms: Initially designed for non-thermal pasteurization purposes, since the inactivation mechanisms of micro organisms via high pressure differs from conventional thermal processing, unique HP applications could be identified. Currently the most successful industrial applications are dealing with the successful inactivation of estrogenic micro organisms such as Salmonella and Listeria [4]. Selective inactivation of micro organism by high pressure treatment has also been applied at industrial scale. Inactivation of yeast by HP treatment, while retaining viable probiotic cultures, in yoghurt has been developed by a large New Zealand company,

HP modifications

Additionally, it could be shown, that HP at room temperature can effectively gelatinise/inactivate proteins and polysaccharides which result in different functionality as compared to thermally induced gels. Thus, combinations of pressure and temperature treatment can lead to unique and novel structures and functionalities of polysaccharide or protein gels. Further inactivation, including selective inactivation (activation of enzymes under HP treatment could be shown [5]. It can also be shown [6], that probiotics can be heat stabilized by low HP treatment and thus can be preserved via spray drying [7], a process which requires 4000-6000 KJ per

kilogram of water removal as opposed to freeze drying where 100,000 KJ are required; processing times of 24 to 48 hours are needed during spray drying.

HP biotransformation

Proteins in aqueous solution respond to compression by reversible or irreversible conformational changes mainly in their tertiary and quaternary structure. The free volume as a result from imperfect molecular packing determines the sensitivity of proteins against pressure which is producing a contraction in volume. Heating has the opposite effect and causes stronger molecular fluctuations and thus an increase in free volume. Consequently, exposure to combined pressure–temperature conditions may result in elliptical diagrams for protein stability or isokineticity plots of enzymes. The non-elliptical, skewed curve for prion inactivation is most likely explained by a solely hydrolytic attack due to the high temperatures at which the prion protein tends to disintegrate [2].

Starch can undergo a transition to a more favourable conformation under pressure. Amylopectin which is located in the crystalline lamellar structures of the growth rings converts from the A to the B-isomorph. The occurrence of elliptical curves for starch gelatinization may result from the prevention of side by side dissociations and helix unwinding because of van der Waals and hydrogen bonds which stabilize the amylopectin helices [2].

Viral inactivation such as Avian flu virus or foot and mouth virus could be inactivated effectively by HP and moderate temperature treatment of up to 50 °C [8, 9].

High pressure treatment at high temperature

High pressure thermal processing as a combined technique can homogeneously heat up and cool down products, and it allows the accurate control of the treatment intensity required for bacterial spore inactivation [10]. Apart from consumer benefit like enhanced product quality, a key advantage of sterilization under high pressure is its applicability to packed food, making obsolete efforts to prevent recontamination or an aseptic filling process [11]. Industrial equipment exists with volumes up to 50 L, 700 MPa maximum working pressure and initial temperatures of up to 95 °C (Uhde High Pressure Technologies GmbH, Hagen, Germany; Avure Technologies, Kent, WA, USA). Although it is widely accepted that sterilization under high pressure is environmentally friendly and can retain the fresh-like characteristics of foods better than heat treatment, it has not yet been successfully introduced into the food industry---possibly due to the less known inactivation mechanisms of high resistant bacterial spores.

High pressure treatment at low temperatures

Pressure-temperature phase diagrams for water show that at 200 MPa the freezing point of water can be lowered to -20°C. This allows cooling under pressure with subsequent pressure release to obtain instant and small ice crystal formation leading to high product quality for frozen products. Alternatively frozen product when subjected to pressure transform from the solid state into the liquid one, can then "thawed" rapidly" with minimum structural damage of the products. Under pressure 12 modifications of ice have been identified. Ice I the ice formed under atmosphere conditions has approx 10 % larger volume than water and thus structured damage occurs upon freezing and thawing of biological materials. However, freezing and thawing under pressure can result in phase transitions with limited volume changes and consequently

with minimum structured damage of food products. On the other hand transitions of ice I to other ice formations (e.g. ice III) under pressure which are denser than water, and the subsequent volume changes which occur in the frozen, solid state can be used to inactivate pathological micro organisms in frozen materials [12].

Novel food and consumer awareness

High pressure treated products have been introduced at an industrial scale in Japan in 2000 and in Europe and the USA in 2006. The introduction of high pressure treated fruit juices in France in 2006 has been considered small scale. Novel Food legislation applies to the process. Novel Food legislation is relevant for any new process introduced to the European Market after May 15, 1997 with less than substantial amounts of products produced prior to that date. However, substantial equivalency of a HP processed product in comparison to a traditionally processed product can be proven then no Novel Food approval is required. So far, all applications for HP treated products in Europe could prove substantial equivalence. The German Research Foundation conducted a thorough evaluation regarding the safety assessment of high pressure treatment and concluded:

"Hitherto, investigations on high pressure treated foodstuffs have not revealed any evidence of any microbial, toxicological or allergenic risks as a consequence of high pressure treatment. However, these findings do not suffice for a general evaluation, because they derive from only a few already marketed products. At present it is necessary, when a new product category is involved, always to carry out an individual case-by-case examination of high pressure treated foodstuffs. In the future it would be desirable to develop product- and process-specific test parameters, in order to be able to carry out any future safety evaluation of high pressure treated foodstuffs according to recognised standard criteria." [13].

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Nanotechnology in functional foods

By Vic Morris, Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA, UK
e-mail: vic.morris@bbsrc.ac.uk

Outside the EU there are a growing number of 'nanofoods' appearing on the market. An important growth area appears to be in functional foods and 'nanoceuticals'. So what is nanotechnology and why is it being used to generate new foods?

Nanoscience involves studying phenomena or manipulating materials at the atomic, molecular and macromolecular scale, and nanotechnology is how such science is used to produce products. This is the science and technology of very small materials. To place this in context, a nanometre is 10^{-9} metre or, for the layperson roughly one hundred-thousandth of the width of a human hair. Producing very small particles or structures alters their properties and this control of their behaviour is why nanotechnology is considered to be important for generating new functional properties.

Food nanostructures

There are many ways to modify the functional properties of foods. Foods are molecular in character and many of the food structures present in raw materials, or those created in processed foods, are self-assembled molecular structures. At present, many of these structures are selected or created in an empirical fashion. However, nanoscience is now beginning to allow the visualisation of such structures and nanotechnology is suggesting ways to select or design the structures in a rational fashion.

Nanotechnology has become prominent because of changes that have occurred over the last 25 years. A key factor has been the emergence of new tools for imaging and manipulating materials at the molecular or atomic level. Probe microscopes (like the atomic force microscope or AFM) allow monitoring or manipulation of materials and processes at the nanoscale. This led to the emergence of what is now called nanotechnology.

A good example of the power of nanoscience is how it has improved the control of the quality of food foams and emulsions. When foams (e.g. the head on a glass of beer) or an emulsion (sauces, creams, yoghurts, butter, margarine) are created this generates gas

bubbles, or droplets of fat or oil, in a liquid medium. This involves producing an air-water or oil-water interface and the molecules present at this interface determine its stability. These structures are one molecule thick and are examples of 2-dimensional nanostructures. Proteins form stable interfaces but the presence of small molecules such as surfactants (soap-like molecules or lipids) causes instability leading to the foam collapsing or the emulsion separating back into oil and water layers. Nanoscience in the form of AFM explains this [www.ifr.ac.uk/spm/]. It shows that the proteins at interfaces form networks and, in order to displace the proteins, the surfactants have to break the network. Proteins used to stabilise food foams and emulsions always form networks so that this newly identified displacement mechanism is generic. New generic strategies can, therefore, be created for improving the stability of the protein networks and this can be applied widely in the baking, brewing and dairy industries.

Proteins and surfactants naturally self-assemble at interfaces. By controlling the types of materials that reach and assemble at the interface, it is possible to build interfacial structures and control their functional properties. Thus, the types of interfacial structure desired can be prepared and their properties controlled. This is really nanotechnology, but the processing tools are familiar and conventional. The same methodology can be used to design and construct surface coatings and barriers. Barriers can be constructed to prevent water absorption or their porosity can be controlled for encapsulation and release applications. In these types of applications nanotechnology is being used to facilitate traditional approaches to food production and storage.

Nanoparticles in foods

An area which has attracted both excitement and concern is the prospect of introducing nanoparticles into foods to generate novel functionality.

Why do we want to introduce nanoparticles into foods? When we change the size of particles we change their properties. One area where reducing the size of the particles present in foods affects functionality is in bioavailability and the delivery of minerals and nutrients. Nanotechnology provides a possible alternative to traditional methods of encapsulation in the production of supplements. Hydrophobic materials in the form of nanoparticles can be made dispersible in water. For example, materials can be trapped in nanocages or micellar structures enhancing their delivery and nanoparticles can penetrate into regions that normal particles cannot reach. Food products incorporating these types of structures are beginning to emerge on the market. Examples include a β-carotene product produced by BASF, nanotea a Chinese product intended to enhance Si supplementation, and Canola Active Oil an Israeli product, claimed to reduce cholesterol absorption by direct delivery of phytosterols to bile salt micelles through the use of a miceller (nano) delivery system. Clearly there are many opportunities, but there are also concerns.

Nanoparticles are being considered for use in food because they offer novel properties. The concern is whether we know enough about their behaviour to ensure that they are safe for use in food. There is concern that nanoparticles may be more toxic than the normal macroscopic material. At present, very little is known about the bioaccumulation or penetration of nanoparticles within the body on ingestion, or the toxicity of these materials. In cases where the nanoparticles are natural products readily broken down and

metabolised in the body, there may be less concern about their use and clearance may be more straightforward. For inert materials which may accumulate in the body, there may be more concern, and these materials may be harder to clear for food use. We know that nanoparticles of silver are being used as surface coatings to prevent fungal and microbial growth. Other nanoparticles of inert materials may show similar behaviour. As yet we do not know what impact introducing such nanoparticles into the gut could have on the gut microflora and our health? It is these types of novel questions that need to be identified, asked and answered if these materials are to be used in foods. Thus it is important to (i) balance both the risks and the benefits of this emerging new technology, and (ii) to ensure that consumers are kept informed about developments and offered choice in the use of such products.

Regulation, labelling and public perception

The development and use of nanotechnology in food may test current procedures for regulation and labelling of foods. How such issues are handled, the transparency of the procedures used to regulate the use of nanotechnology in food, and the types of products produced, are likely to be a major factor in influencing public attitudes. Ultimately, public perception may be the most important factor determining the impact of this new area of science in the food industry and regulatory authorities and food companies need 'to watch this space'. To facilitate such debate, the Institute of Food Research (IFR) in Norwich, UK has generated a website [www.ifr.ac.uk/spm/nanotechnology.html] providing access to information on nanotechnology specifically related to its potential applications in food. The site provides links to (i) sites describing new products, (ii) bodies regulating nanotechnology and research in the area, and (iii) sites discussing the pros and cons of this technology.

APPENDIX 1: Functional food projects funded by the EU

(List prevailing in January 2006-March 2009)

A selection of EU-supported R & D projects in functional foods is listed below together with web site details (if available). These projects may be totally on functional foods or may contain a component that relates to functional foods:

Adolescence: Healthy lifestyle in Europe by nutrition in adolescence (HELENA) www.helenastudy.com

Allergy: Plant food allergies: field to table strategies for reducing their incidence in Europe http://www.akh-wien.ac.at/safe

Allergy: Reduced allergenicity of processed foods (containing animal allergens) (web not yet available)

Antioxidant: European research on functional effects of dietary antioxidants http://www.ifr.bbsrc.ac.uk/EUROFEDA

Antioxidant: Improved antioxidant content for food applications (web not yet available)

Antioxidant: Health implications of natural non-nutrient antioxidants (polyphenols): Bioavailability and colon carcinogenesis (web not yet available)

Beef: Enhancing the content of beneficial fatty acids in beef and improving meat quality for the consumer http://www.healthybeef.iger.bbsrc.ac.uk

Caffeine: Dietary caffeine, health and quality of life in Europe (web not yet available)

Cancer: Functional food against colon cancer: Development of a genomics and proteomics based screening assay (web not yet available)

Carotenoids: Production of fungal carotenoids for healthy nutrition (web not yet available)

Cereal grains: Exploiting bioactivity of European cereal grains for improved nutrition and health benefits (HEALTHGRAIN) http//:www.healthgrain.org/pub/

Cheese: Constructing tailor-made surface starter cultures for safe production of red-smear cheeses (web not yet available)

CLA: Conjugated linoleic acid (CLA) in functional food: A potential benefit for overweight middle-aged Europeans http://www.teagasc.ie/research/dprc/biocla/index.htm

CLA: Production of CLA-enriched dairy products by natural means (web not yet available)

Claims: A process for the assessment of scientific support for claims on foods http://europe.ilsi.org/passclaim

Coeliac: Coeliac disease: A food induced disorder. Exploration and exploitation of Tcell stimulatory gluten peptides http://immunologi.no/cd/index.html

Coeliac: Quantification of coeliac disease toxic gluten in foodstuffs using a chip system with integrated extraction, fluidics and biosensoric detection (web not yet available)

Coeliac: Evaluation of the prevalence of celiac disease and its genetic components in the European population www.technapoli.it/eucluster/eucluster.htm

Edible oils: A new process using membrane reactor technology to improve the healthcare aspects of hydrogenated edible oils http://www.leia.es/Camertoil

Enzymes: Novel enzyme-aided extraction technologies for maximized yield and functionality of bioactive components in consumer products and ingredients from by-products (web not yet available)

Folate: Folate: from food to functionality and optimal health http://www.ifr.bbsrc.ac.uk/folate

Flavonoid: Flavonoids in fruit and vegetables: their impact on food quality, nutrition and human health http://flavo.vtt.fi

Flavonoid: Flavonoids and related phenolics for healthy living using orally recommended antioxidants http:// biopolo.it

Fruit: Increasing fruit consumption through a trans disciplinary approach leading to high quality produce from environmentally safe, sustainable methods (ISAFRUIT)
www.isafruit.org

Garlic: Garlic and health: The development of high quality garlic and its influence on biomarkers of atherosclerosis and cancer in humans for disease prevention http://www.plant.wageningen-ur.nl/projects/garlicandhealth

GI tract: The food, GI-tract functionality and human health cluster http://www.vtt.fi/virtual/proeuhealth/

Glucan: Barley beta-d-glucan and wheat arabinoxylan soluble fibre technologies for health promoting bread products
http://www.solfibread.com

Glucan: Design of foods with improved functionality and superior health effects using cereal beta-glucans
http://www.bionutr.kc.lu.se/betaglucan/index.html

Glycosidase: Solving the problem of glycosidase inhibitors in food processing (web not yet available)

Grain: Exploiting bioactivity of European cereals for improved nutrition and health benefits (HEALTHGRAIN)
http://www.healthgrain.org

Gut health: Networking in associated Candidate Countries towards food GI-tract functionality and human health
http://proeuhealth.vtt.fi

Gut microbiota: Functional assessment of interactions between the human gut microbiota and the host
http://www.vtt.fi/virtual/proeuhealth/

Gut microflora: Functional food, gut microflora and healthy ageing
http://www.vtt.fi/virtual/proeuhealth/

Isoflavone: Isoflavones for reducing risk of coronary heart disease among postmenopausal women (web not yet available)

LAB: Biosafety evaluation of probiotic lactic acid bacteria used for human consumption (PROSAFE) www.vtt.fi/virtual/prohealth/

LAB: Fermentation of food products: optimised lactic acid bacteria strains with reduced potential to accumulate biogenic amines http://decarboxylate.cib.csic.es

Lipid: The role of lipids in neurodegeneration and their preventive potential in diet
www.lipidiet.org

Lupin: Optimised processes for preparing healthy and added value food ingredients from lupin kernels, the European protein-rich grain legume http://users.unimi.it/healthyp/index.html

Lycopene/tomatoes: The role of lycopene for the prevention of cardiovascular disease (LYCOCARD). www.lycocard.com

Metabolic syndrome: Diet, genomics and the metabolic syndrome: an integrated nutrition, agro-food, social and economic analysis (LIPGENE) www.lipgene.tcd.ie

Novel food: Quantitative risk assessment strategies for novel foods http://www.noforisk.org

Nutraceutical: Increase in nutritional value of food raw materials by addition, activity, or in situ production of microbial nutraceuticals http://www.nutracells.com

Nutraceutical: Local Mediterranean food plants: Potential new nutraceuticals and current role in the Mediterranean diet (web not yet available)

Nutraceutical: Nutraceuticals for a healthier life: n-3 polyunsaturated fatty acids and 5-methyl-tetra-hydro-folate (web not yet available)

Obesity: Nutrigenomics and the obesity problem:- hype, help or hope (DIOGENES) www.diogenes-eu.org

Olive oil: The effect of olive oil consumption on oxidative damage in European populations http://www.kepka.org.eurolive

Olive oil: Setting up an network of technology dissemination centres to optimise SMEs in the olive and olive oil sectors http://www.tdcolive.net

Osteoporosis: The prevention of osteoporosis by nutritional phytoestrogens (web not yet available)

Peptide: Hypotensive peptides from milk proteins
www.ul.ie/acepeptides

Phytochemical: Functional properties, bioactivities and bioavailability of phytochemicals, especially anthocyanins, form processed foods
http://honeybee.helsinki.fi/MMKEM/EK/Tutkimus/antho_uusi.html

Phytoestrogen: Improving health through dietary phytoestrogens: A pan-European network on consumers' issues and opportunities for producers (web not yet available)

Phytoestrogen: The role of dietary phytoestrogens in the prevention of breast and prostate cancer (web not yet available)

Prebiotic: Functional foods, gut microflora and healthy ageing (CROWNALIFE) http://crownalife.be

Prebiotic: Synbiotics and cancer prevention in humans (SYNCAN)
http://www.syncan.be

Prebiotic: Functional assessment of interactions between the human gut microbiota and the host
http://www.eumicrofunction.be

Pro- Prebiotic: Nutritional enhancement of probiotics and prebiotics: Technology aspects on microbial viability, stability, functionality and on prebiotic function
http://www.vtt.fi/virtual/proeuhealth

Probiotic: Probiotic strains with designed health properties
http://www.vtt.fi/virtual/proeuhealth/

Probiotic: Molecular analysis and mechanistic elucidation of the functionality of probiotics and prebiotics in the inhibition of pathogenic microorganisms to combat gastrointestinal disorders and to improve human health http://www.vtt.fi/virtual/proeuhealth/

Probiotic: Probiotics and gastrointestinal disorders: Controlled trials of European Union patients
http://www.vtt.fi/virtual/proeuhealth/

Seafood: Health promoting, safe seafood of high eating quality in a consumer driven fork-to-farm concept (SEAFOODPlus)
http://www.seafoodplus.org

Seafood: Improved quality of smoked salmon for the European consumer http://www.mmedia.is/matra/eurosalmon

Seafood: Utilisation and stabilisation of by-products from cod species http://kibt.chembio.ntnu.no/fishbyprod

Seaweed: Seaweed antioxidants as novel ingredients for better health and food quality (www.sea-health.org)

Starch: Stable isotope applications to monitor starch digestion and fermentation for the development of functional foods http://www.eurostarch.org/

Vitamin: Fat-soluble vitamin status and metabolism during ageing: Functional and nutritional consequences (web not yet available)

Vitamin D: Towards a strategy for optimal vitamin D fortification (OPTIFORD) www.optiford.org

Zinc: Zinc effects on nutrient/nutrient interactions and trends in health and ageing http://www.inra.fr/zenith

APPENDIX 2: Key contact organisations and agencies involved with functional foods

(List prevailing in January 2006-March 2009)

Key contacts and networking represented a strategic part of the FFNet project in realising innovative outcomes and potential business opportunities in functional foods. Details of **organisations/agencies** in the EU involved in functional foods are listed below:

Alimentary Pharmabiotic Centre (IE): links Irish science with industry and society through excellence in research, education and outreach in gastrointestinal health www.apc.ucc.ie

Ashtown Food Research Centre (Teagasc) (IE): Conducts a dynamic nationally and internationally funded food R & D

programme coupled with follow-through innovation activities for the Irish food industry www.ashtownfood.ie

British Nutrition Foundation (BNF) (UK): This is a registered charity to promote wellbeing of society through the impartial interpretation and effective dissemination of scientific based knowledge and advice on the relationship between diet, physical activity and health http://www.nutrition.org.uk

Community Research & Development Information Service (CORDIS): (i) facilitates participation in European research and innovation activities, (ii) improves exploitation of research results with emphasis on sectors crucial to Europe's competitiveness, (iii) promotes diffusion of knowledge fostering the innovation performance of enterprises see:
http://cordis.europa.eu.int/en/home.html

CIAA-Confederation of Food & Drink Industries: CIAA's mission is to represent the food and drink industries' interests, at the level of both European and international institutions. CIAA participates pro-actively in the development of an environment where all European food and drink companies (whatever their size) can compete effectively for sustainable growth in the context of an enlarged EU and global markets, as well as meeting consumers' needs. Moreover, CIAA contributes to the development of a legislative and economic framework addressing competitiveness, food quality and safety, consumer information.
http://www.ciaa.be/pages_en/homepage.asp

CyberColloids Ltd: was developed from a vision to form a global centre of excellence for hydrocolloids. It offers a unique range of services covering research, innovation, manufacturing excellence,

outsourcing strategies, process and product development as well as sales and technical marketing support www.cybercolloids.net

Europa-EUR-Lex: provides direct free access to European Union law including those pertaining to functional foods www.europa.eu.int/eur-lex/lex/en/index.htm

European Food Information Council (BE): gives the basics on functional foods; what, why, how? http://www.eufic.org

European Food Safety Authority (EFSA): is the keystone of European Union (EU) risk assessment regarding food and feed safety. In close collaboration with national authorities and in open consultation with its stakeholders, EFSA provides independent scientific advice and clear communication on existing and emerging risks www.efsa.eu

European Institute of Technology (EIT): The EIT is Europe's flagship for Excellence in Research, Education and Innovation. The EIT will help make Europe more competitive on the global scene. It will unlock Europe's potential for innovation and is not constrained by barriers between research, education and business. EIt's main mission is innovation, but its architecture is in innovation as well. As a flagship of excellence, the Institute will be able to attract the best students and researchers worldwide. See--- http://ec.europa.eu/education/policies/educ/eit/index_en.html

Food Chain Centre of Industrial Collaboration (UK): The Food Chain CIC is involved in delivering the power of science to food and drink companies in order to solve their problems and improve their production and products http://www.FoodChainCIC.co.uk

Food Ingredients First (NL): is a magazine hosted by CNS MediaBV on food-ingredient technology and food product development www.foodingredientsfirst.com/

Food Navigator.com: is a free newsletter which delivers breaking news on food and beverage development www.foodnavigator.com

Food Science Central (FSC): is produced by *IFIS* Publishing, the producers of FSTA – Food Science and Technology Abstracts. FSC is a gateway to free and subscription based information relating to the *world* of food science, food technology and food-related human nutrition www.foodsciencecentral.com

Food Technology Centre (Wales, UK): This Centre is involved in a wide range of activity in food R & D and has a strong programme on-stream for SMEs and other food companies in Wales and elsewhere www.foodtech-llangefni.co.uk

Functional Foods & Nutraceuticals: is a magazine supplying information on trends and movers in the functional foods and related areas www.ffnmag.com/ASP/currentissue.asp

Functional Foods Forum (FI): was established to strengthen multidisciplinary research on food and health in the Turku region of Finland www.utu.fi/fff

International Life Sciences Institute (ILSI Europe) (BE): information on many aspects of functional foods, and especially on regulations and claims. http://europe.ilsi.org/

Institute of Food Science and Technology (IFST): is the leading EU qualifying body for food scientists and technologists. It

issues Information Statements on hot issues in food on an ongoing basis www.ifst.org

Nordic Innovation Centre (NICe) (NO): promotes an innovative Nordic food industry in a range of areas including functional foods www.nordicinnovation.net

Nordic Network for Marine Functional Food (MARIFUNC)(NO): The main objective is to strengthen the marine based industry in the Nordic countries in the development of innovative marine functional foods or marine food ingredients taking into account consumer's needs and attitudes www.marifunc.org

Øresund Food Network (DK): is a Danish/Swedish network in food related issues in the whole value chain. www.oresundfood.org

The Institute of Food Technologists (IFT) (USA): publishes news, articles, and other information of interest to food scientists, food technologists and personnel in related fields http://members.ift.org/IFT/Pubs?CRFSFS and www.ift.org/cms/

ACKNOWLEDGEMENTS

We thank the Commission of the European Community for funding the FunctionalFoodNet (FFNet) project (January 2006-March 2008) as part of the 6th Framework Programme [Priority: Food Quality and Safety, FP6-2003-Food-2-B, Specific Support Action entitled '' Exploitation of functional food science by creating a European network of food industries (FunctionalFoodNet)'' Contract No. 517817].

Thanks are also extended to the authors of the 42 articles presented in this publication. Their rapid and courteous response to the request to write each article is greatly appreciated.