A Farmers Fund Food Chain Award

‘Crops for Functional Food’

by
Geraint Hughes
Fferm Iocws
Pwllheli
Gwynedd
LL53 5TY
geraint@madryn.co.uk

WELCOME

Welcome to my Nuffield report.

I have intentionally adopted an informal writing style to my report. The Nuffield experience for me was an opportunity to step outside the lab and go beyond field trials to study the bigger picture. It meant pondering in my bed as opposed to measuring leaf cover, it meant moulding my own philosophy rather than being told what to think, and it meant gauging perceptions rather than analysing statistical variances.

My scholarship was the start of a new journey for me, one that I continue on today. Journeys are best described with stories, hence the rather unusual approach to my report. My intention is for you, the reader, to enjoy it whether you're sitting behind a desk or slouched on your sofa. I want my report to be left in the magazine rack or on the communal coffee table, not on the top shelf gathering dust.

Agriculture is my 'occupassion.' I am proud to be part of this dynamic industry, responsible for putting food on tables, laps and dashboards. I was 27 when I embarked on my study, and even then I knew that not many of us get out of this lifetime alive! Western world populations are blighted with diseases and ill health. My scholarship taught me that the solution is in the hands of agriculturalists, not the pharmaceutical conglomerates.

Having been bought up on a dairy farm in the far corner of north west Wales, I was fortunate enough to feast on unpasteurised milk, Welsh mountain water, eggs from free roaming chickens and rhubarb, apples and carrots from bottom of the garden. It took a Nuffield Scholarship for me to really appreciate this luxury.

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DIOLCH

Hoffwn ddiolch i bawb alluogodd i mi gyflawni yr ysgoloriaeth hon. Rydych yn llawer rhy niferus i mi'ch rhestru chi gyd.

Mi welais yr ochr orau o ddynol ryw yn ystod fy nheithiau. Cefais fy llochesu, fy mwydo a fy nghysuro gan bobl oedd tan y foment honno yn gwbl ddiethr i mi.

Diolch arbennig i Ymddiriedolaeth Nuffield am roi y cyfle yma i mi, ac am gefnogaeth ac amynedd cyson Mr John Stones, Cyfarwyddwr yr Ymddiriedolaeth. Hoffwn ddiolch yn ddiffuant a chydnabod cefnogaeth ariannol a dderbyniais gan y 'Farmers Food Chain Award' a alluogodd i mi ymgymryd â'n nheithiau cofiadwy.

Ni fyddai wedi bod yn bosib i mi ymgymryd a'r daith hon heb gefnogaeth fy rhieni a Meinir fy nghymar. Diolch arbennig i chi.

THANKS

I would like to thank everybody who enabled me to complete this Scholarship. You are far too numerous for me to start listing.

I saw the very best side of people on my travels. I was sheltered, fed and comforted by people who were up to that point complete strangers to me.

A special thank you must go to the Nuffield Trust for providing me with this opportunity, and to the constant support and patience of Mr John Stones the Trust's Director. I would sincerely like to thank and acknowledge the financial support I received from the Farmers Food Chain Award, which enabled me to embark on my memorable journeys.

It wouldn't have been possible however without the unfaltering support of my parents and my partner Meinir. Thank you.

"The doctor of the future will give no medicine but will interest his patients in the care of the human frame, in diet, and in the cause and prevention of diseases."
– Thomas A Edison, 1903

FOREWARD

Some way along our journey of industrialisation, we have forgotten the meaning of eating food. Most of us consume food for the sake of having to do it.

In one sense I am fascinated by our relationship with food, and yet I am disgusted. Eating should be the most important task we do each day, not an inconvenience.

My report takes a serious look at the functionality of food. We are over fed but under nourished. Never has food been so abundance, but rarely has it ever been so nutritionally lacking at the same time, and that's official.

I was struck at the rate of deterioration of some nutrients from our food and the health implications of this. What makes it even more frustrating is that whilst it's well within our capabilities to nourish people we're failing because the system encourages quantity over nutritional quality.

The report outlines a possible solution to reverse this decline that also simultaneously improves the sustainability of farming. The simple truth is that what is good for the land is good for people.

Eating is an agricultural act. Our customers want to stay healthy. Health is set to become an even stronger market driver for the future. All of this is extremely good news to farmers.

All farmers are crop growers. Some grow grass whilst others grow salad. Plants grown properly in well managed soils will give better nutritional reading. A simple hand held device called a refractometer can be used to measure this.

The crux of my report is based on developing this system as a basis for calculating payments to growers to encourage better nutrition, and to allow customers to make more informed choice in shops rather than the usual lottery of hand picking produce without any idea of whether it's nutritionally good or bad.

At the same time, there are lucrative opportunities for crop growers who wish to capitalise on the growing trend for functional food. Plants offer an immense array of chemicals that can provide us with impressive health benefits.

The report outlines the current state of play for food health claims and highlights key market opportunities.

In summary, the nation's health is in our hands, and we can deliver.

INTRODUCTION

Like many parts of the UK, agriculture in west Wales has become dominated by grassland based systems. This wasn't the case 3 or even 2 generations ago.

Fertile coastal land used to produce rich crops of vegetables and cereals that not only fed the local population but also supplied towns and cities several hours drive away. Fast forward to 2009 and the vast majority of farms in Wales can be labelled dairy, beef, sheep or a mix of these.

Our dependency on a narrow range of farming systems cannot be sustainable in light of future challenges. I believe UK agriculture will have to diversify within agriculture.

In August 2009, DEFRA launched a consultation on Food Security in Britain. This signalled a significant turning point for food and farming policy in Britain.

The last time a food strategy was launched in the UK, it was Luftwaffe bombs that caused the biggest concern for consumers. Now, spiralling prices, climate change and green issues has once again bought food to the forefront of policy makers' minds.

According to DEFRA, the UK is only 60% self-sufficient in all foodstuffs, and 73% in indigenous produce. The trend is set to continue downward unless a deliberate effort is made to reverse the decline.

Crops of all kinds will have to play a bigger role if we are to successfully adapt to climate change, improve our self-sufficiency and protect our economy from the recent roller-coaster of commodity prices.

In tandem with these developments, I have watched the staggering growth of functional foods. In the 10 years between 1997 and 2007, the market has grown from being worth £134million to £1.7billion (Mintel, 2007.)

The dairy sector has grasped the opportunities offered by time short consumers seeking food that will provide them with that extra health edge. Knowing how many of our medicine hails from plant discoveries, there surely must be numerous opportunities for growers to cultivate crops to produce functional food?

AIMS AND OBJECTIVES OF MY TRAVELS

The main aim of my study was to improve my understanding of how crops could be cultivated to produce functional foods that will in turn offer farmers a commercial opportunity and improve people's health.

To provide a particular focus to my exploration, I decided that I needed to do the following:

1. Establish what exactly is meant by functional food and how is it policed?
2. Visit pioneering companies who had successfully built businesses on functional crop products.
3. Identify innovative examples of functional crop products.

BACKGROUND

To live we need shelter, water, oxygen and food.

In Britain, like most parts of Western Europe, Japan and North America, only a small minority have to worry about their basic needs.

At the other end of the spectrum, populations in sub-Sahara Africa fight for their survival on a daily basis. Eating there is all about surviving to the next day.

It wasn't too long ago that people in this country had the same gruesome daily outlook. With the onset of industrialisation, our standard of living improved.

Our diet gradually evolved to include more staples such as bread and potatoes. Greater wealth introduced new tastes to our tables such as meat, dairy products, oils and sugars. It is at this stage that China finds itself now.

Further on they too will demand higher quality premium products offering greater convenience. The western world diet by then is expected to include even higher complexity incorporating nano technology solutions to nutrients and personal diets to match our gene profile.

Food and farming is the same one industry, so we as agriculturalists should be just as aware of these trends as we are of fluctuating diesel prices. Detaching farming from food has only benefitted other players in the supply chain.

Food processors, retailers and researchers told me that health will become the key market driver in the future, but consumers will still expect convenience and quality.

I wanted my study to offer me the time to consider ways of improving the link between farming, food nutrition and health. Having managed commercial crop trials for 5 years at the University of Wales Bangor, I wanted to focus on plant based products.

WHAT ARE FUNCTIONAL FOODS?

In typical jargon fashion, few know what is meant by functional food, even those who talk about it. Legally, a functional food should provide a health benefit beyond basic nutrition. Market intelligence data and statistics will typically keep to this definition. However, I am not comfortable with this definition.

For a food item to be considered functional depends in my opinion on consumer perception. For example, an identical punnet of blueberries might appeal to one person because of their attractiveness and sublime taste with vanilla ice cream. Whilst another person could pick the same punnet because they know that blueberries are an excellent source of antioxidants which will reduce their chance of contracting cancerous growth. The latter has bought functional food, whilst the former bought a refreshing desert.

Functional food is far more than just the legal definition as it reflects the ever evolving change in our relationship with food. No longer do we eat to survive. We consume food to enjoy and improve our standard of life. Whether an item of food can be called functional depends on what drives the consumer to make the purchase. They are bought because of a belief it will improve a particular aspect of their health.

Our understanding of food is improving all the time, even if we are just scratching under the surface as Dr Ander Anderssen a practicing physician and agronomist from Indiana, USA explained to me. Little did everyday jargon such as omega-3, polyunsaturated fats, antioxidants, plant sterols and flavonoids feature in our language 25 years ago, let along 50 years ago.

ABOVE: A selection of popular functional food.

Consumers have to be informed to choose functional foods. They can be labelled accordingly to highlight their potential health benefits. People may read articles or hear interviews on specific food items to spur them to eat or drink that product.

The legal definition needs an extra caveat in my opinion if we are to truly understand our developing relationship with functional food. Functional food have a perceived health promoting or disease preventing property beyond the basic function of supplying nutrients, and is bought by the consumer for that reason. How the customer arrives to that perception can vary.

A Japanese government initiative in the mid 1980s called 'Food for Specified Health Use' gave us the term functional food, but since then the concept has also been tagged as smart food, medicinal food and super food.

There are 3 distinct categories of functional food in my opinion, of which I have named as the following:

i) **NATURAL** – These are food items that have naturally occurring compounds that are proven to be health beneficial or disease preventative beyond their basic function of delivering nutrients. Blueberries, broccoli, prunes and salmon are examples of natural functional foods.

ii) **MANIPULATED** – Production systems can be adapted to convert standard food into functional food. The most common example of this is manipulating animal feed. For example, Omega-3 rich eggs are produced by feeding chickens with specially formulated fee. Another example would be the work done by scientists who have genetically modified a high lycopene tomato strain that could decrease the risk of contracting cardiovascular diseases and cancerous growth.

iii) **PROCESSED** – The dairy sector is dominated by artificially enriched functional products. The characteristics of these food are typically adapted during the processing phase in factories and may involve adding or/and extracting compounds and micro-organisms. The yogurt market in recent years has successfully innovated into the functional market through developing a range of health beneficial bacteria that can be consumed to improve body functions such as digestion and circulation.

Functional food is not a fad. Reports from all the countries I visited, including the USA, Germany, Franc e and Belgium stated that food functionality is set to take over from convenience as the main driver in food evolution. The successful products will be those that can deliver on all key fronts – health, convenience and quality.

British farming needs to realise this urgently, or it will have missed this golden boat as well. In 1997 the market stood at £134m. By 2007 it had grown to £1.7bn with the growth curve according to Mintel the market intelligence specialist set to get even steeper.

CASE STUDY 1

Valorex – Linseed is among the oldest cultivated crops by man providing fibre for clothes, oil for treating wood and seed for feeding humans and animals.

It was during my visit to France that I came across Valorex. Formed in 1992 by a team of animal and human nutritionists, they set out to transform the way linseed was utilised as feed in animals.

The Valorex team were aware of the consequences of intensive agriculture in switching livestock diets from grass to cereals. A grass based diet will provide omega-6 and omega-3 essential fatty acids in the ratio of 1:1 as required to maintain a healthy body. Animals reared on wheat, maize and soya rations however are given a ratio of 40:1.

Humans as consumers of animal products inherit this deficit of omega-3, which is only made worst by the excessive ratio. The body uses the same family of enzymes to digest both fats, but given the choice, it will typically digest omega-6 before omega-3. In reality the ratio is more critical than the total intake of omega-3.

Despite this, we are bombarded by messages to increase our omega-3 intake, but as I found out on my Nuffield, we could do equally well to reduce our intake of omega-6.

Valorex processes 140,000t of linseed at their processing plant each year in Combourtille, Brittany. Firstly, the seeds are grinded before passing through a steam treatment to detoxify cyanogenic compounds and improve the availability of the oil. The extruded linseed is bagged in pellet form ready to be fed to farm livestock.

ABOVE: Selection of French products carrying the Bleu Blanc Coeur Logo.

What impressed me the most with Valorex was their involvement with partners along the whole supply chain. The company established a not for profit organisation in 2000 to market the benefits of feeding livestock with their linseed feed. Bleu Blanc Coeur (which translates to Blue White Heart) is an association with over 200 commercial members ranging from plant breeders, farmers, slaughter houses, dairies, feed merchants and supermarkets right across France. In 2007, over 150 products could be found on supermarket shelves carrying the Bleu Blanc Coeur logo.

This powerful combination of scientists, producers, processors and retailers had led to a range of products that utilised Valorex's feed, worth over €100m. Valorex is a truly pioneering company.

POLICING HEALTH CLAIMS

Functional food is one area where we need to be extra friendly with civil servants, as only they can provide the necessary structure to ensure food labelled with health claims are genuine. Unless health claims are properly policed, consumers will lose confidence, but worst still we will have lost an opportunity to improve our diets.

In this respect, Europe has taken the lead. In December 2006, a Regulation on the use of nutrition and health claims for foods was adopted by the Council and Parliament, having originally put forward the proposal in July 2003. This Regulation lays down harmonised rules for the use of health or nutritional claims on foodstuffs based on nutrient profiles.

EU legislators and politicians explained to me during my visit to Brussels in 2007 that a successfully implemented Regulation on nutrition and health claims will ensure that any claim made on a food label in the EU is clear, accurate and based on generally accepted scientific evidence. In doing so, it will enable consumers to make informed and meaningful choices when it comes to food and drinks. This should also contribute to a higher level of human health protection, as it ties in with the Commission's campaign for healthier lifestyle choices.

The Regulation also aims to ensure fair competition and promote and protect innovation in the food market, which will facilitate the free circulation of products bearing claims in the European Union.

The rate of execution of this much needed piece of Regulation has been painfully slow. It took until December 2007 for Member States to receive formal guidance on implementing it.

Up to March 2007, health claims made in the UK had to be substantiated by the Joint Health Claims Initiative (JHCI.) The JHCI was an independent coalition consisting of various consumer groups, food law enforcement agencies and food industry bodies representing processors and retailers.

Established in 2000, its initial task was to draw up a voluntary code of practice to ensure health claims did not mislead consumers. It was considered by most members to be an interim solution during the absence of specific legislation. With the imminent onset of the EU Regulation, JHCI closed its doors in March 2007 and transferred its files to the Food Standards Agency who will implement the new Regulation on behalf of the British Government.

Following years of wrangling, the new EU regulation 1924/2006 on Nutrition and Health Claims began to apply harmonised rules across Europe from 1st July 2007. Member States are now in the process of contributing towards an EU-wide list of claims based on generally accepted science. In the UK, the Food Standards Agency will assume this responsibility. The Regulation is now timetabled to come into force on 19th January 2010, nearly 7 years after it was initially proposed.

Previous to this, the JHCI had only recognised 5 health claims in the UK. The new structure will open the doors for a much bigger choice of health claims over the coming years. However, applying for a new health claim is going to be prohibitively expensive for SMEs, especially if detailed scientific trials are required to produce the necessary evidence.

A health claim means any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its components and health. Different types of health claims will be authorised by the European Commission.

For the first type, the so-called 'function' health claims, an EU positive list will be drawn up by the Commission. This list will consist of well established health claims relating to the growth, development and the functions of the body.

In addition, health claims referring to the reduction of a risk factor in the development of a disease and health claims referring to children's development and health will be authorised, such as "Plant stanol esters have been shown to reduce blood cholesterol. Blood cholesterol is a risk factor in the development of coronary heart disease" and "vitamin D is needed for children's bone growth and development".

Only the large organisations are expected to apply for new claims, but once approved, they will be open for adoption by all companies. In this respect, manufacturers will have to work closely with growers to ensure a reliable supply of products.

Farmers and smaller companies will have opportunities to utilise accepted claims or work in partnership with bigger concerns. Either way, as Ridge Shinn a Maryland beef farmer pointed out to me, functional food is difficult to 'McDonaldise.'

CASE STUDY 2

Institute of Food Research (IFR) - Based in Norwich, the IFR undertakes ground-breaking research work in harnessing food for health and controlling food-related diseases. Its mission is to undertake internationally acclaimed research work on food and human health and to work in partnership with others to provide underpinning science for consumers, policy makers, the food industry and academia.

There is no doubt that the Institute produces fine pieces of research under tight financial constraints, and hence their strategy on focusing on key areas. It does however appear alarmingly detached from agriculture, and stronger links with agricultural based R&D stations would in my opinion encourage a faster transfer of knowledge application.

One of its key objectives is to understand exactly how our diet influences our long-term health.

TWO TIER FUNCTIONALITY

New health claims will take years to nurture from initial R&D to being fully accepted by the EU. Companies will expect a higher return from products that have taken up large budgets to develop, which in turn will limit their advance to the most affluence countries that can afford to pay a premium.

Aware that functional food is at the forefront of our dietary evolution, I focused my studies on developed westernised countries. The utilisation of novel crops and a new understanding of micro-chemistry will no doubt offer growers with new commercial opportunities in this market as outlined later on in the report.

It wasn't until I returned home that I realised that everybody who I met was trying to convey a message my blinkers had all along deflected. I was so engrossed by the development of the functional food market that I had ignored the most fundamental message that needed our urgent attention.

People's health is suffering because of their modern diets. The Western world is over-fed and under-nourished.

The latest generation of functional food only allows us to fine tune our bodies. Before that, we need to greatly improve our basic nutritional intake. Bad genotypes may be loading the gun, but as Dr Brian Vonk, a leading American dietician described to me, it's our food that pulls the trigger.

CASE STUDY 3

The Weston A Price Foundation – In the early 1930s, a Cleveland dentist named Weston A Price began a series of unique investigations. Over the next ten years, he travelled to isolated parts of the globe to study the health of populations untouched by Western civilisations. His goal was to discover the factors responsible for good dental health. His studies revealed that dental caries and deformed dental arches resulting in crowded, crooked teeth are the result of nutritional deficiencies and not inherited genetic defects.

The groups Price studied included sequestered villages in Switzerland, Gaelic communities in the Outer Hebrides, indigenous people of North and South America, Melanesian and Polynesian South Sea Islanders, African tribes, Australian Aborigines and New Zealand Maori. Wherever he went, Dr Price found that beautiful straight teeth, freedom from decay, fine physique and resistance to disease were typical of native groups living on their traditional diets, rich in essential food factors.

The Weston A Price Foundation was founded in 1999 as a non-profit tax-exempt charity to disseminate the research of this nutrition pioneer, whose studies established the parameters of human health and determined the optimum characteristics of human diets. Based in Washington DC, USA, the Foundation is dedicated to restoring nutrient-dense foods to the American diet through education, research and activism.

It was no coincidence that nearly all individuals and businesses I visited cited the work of the Foundation. Although their stance on topics such as promoting raw milk and advocating red meat consumption goes against common guidance, the Foundation seemed to demand a universal respect. It would be good to have a UK version.

We eat to get nutrition, yet the production system is geared up to reward volume as opposed to nutritional quality. Food quality is based on show rather than substance. According to MAFF figures published in the mid nineties, food is less nutritious nowadays than it was before the Second World War. Between 1940 and 1991, there was a 46% calcium reduction and 76% less copper in vegetables, and 24% less iron recorded in fruits.

British and American researchers show that fresh fruits and vegetables have lost about 1% of their vitamin and mineral content each year since the Second World War.

Dr Paul Clayton, an immediate past Chair of the Forum on Food and Health at the Royal Society of Medicine, and Scientific Advisor to the Nutritional Therapy Council was invited in 2008 to present his proposals on national health policy to a Government Select Committee. Dr Clayton coined the term 'dys-nutrition' to explain the significant increase in degenerative diseases.

As well as increasing the levels of activity, Dr Clayton argues the need for improved nutrition and higher personal responsibility for diet. In his latest book he claims most people are depleted of most micro-nutrients.

His work highlighted the deficiency of vitamin intake among Americans as summarised in the table below.

Vitamin	%
A	55
C	37
E	68
B1	32
B2	31
B4	34
B6	54
B12	17

TABLE 1: Percentage of USA adult population whose diets do not reach USDA Recommended Daily Minimum Allowance.

I am now convinced that our first priority as producers should be to improve the general functionality of food. Whilst specific health claims should continue to be developed, it should be done with a longer-term view offering immediate premium niches for a minority of growers.

NO SHORT CUTS

Eating is an agricultural act. Recent decades has seen farming becoming ever more detached from food consumers. Specialisation has meant farmers have become core producers who are rarely aware of the latest eating trends. Conversely, consumers show a frightening lack of understanding about food production.

Agriculture, food processing and retailing are all part of the food industry. If we are to achieve a fundamental improvement in food nutrition, the industry has to collectively work together with the full backing of the Government.

Although I have every confidence that this is possible, the British Government's disregard to farming over recent years, especially its R&D base, has meant that farming now faces an even more basic issue of food security. Self-sufficiency is well within our ability, even if the UK population has reached over 61million in 2009.

I suspect if the UK was near or at self-sufficient, the Government would be more likely to respond to the need of improving nutrition. However, there is a way where both self-sufficiency and nutrient enrichment of food can be achieved simultaneously, but it will require a seismic shift in mindset.

Firstly, any obsessions for quick wins must be extinguished. Government and industry alike must take a long-term view.

Secondly, eating and shopping habits must adapt to cut waste and improve health. To be fair, the Government has succeeded to raise people's awareness of healthy eating with campaigns such as '5 a day.' Changes to the school menu are another fine example of Government intervention.

Thirdly, farmers need to be financially rewarded for producing nutritious food. Prices for food commodities are set by yields, so farming has for decades striven for ever higher yields at the cost of taste and nutrition. Research and breeding programmes in the UK are dominated by our understandable fixation for better yields to obtain better prices. We need to make nutrition profitable.

Our current situation is probably a throwback to the Green Revolution that followed the Second World War, but times have changed. Land in the 1950s was fresh and rich in organic matter, and could easily cope with a few years of intense farming methods. Memories of widespread hunger and famine were also on everybody's mind so the intense sense of urgency was understandable.

To continue with the same policy would stagnate our progress in food evolution terms as we need to aim for better quality to improve health. In my opinion, we need to radically change our pricing mechanism to award producers for nutritionally dense food. This I acknowledge cannot take place overnight, but a planned transitional period of say 10 years would suffice to completely overhaul our industry.

Fourthly, sustainability and health issues can be and needs to be addressed holistically. My experience of travelling has clearly demonstrated that a healthy body stems from healthy food. This can be taken back further to that healthy food comes from healthy soils. Healthy soils in turn can only be achieved utilising sound sustainable farming methods.

This must not be confused with advocating organic or other types of environmentally led agricultural systems or misinterpreted as a call for halting scientific advancement. In reality, I'm calling for pursuing modern technology that has shown clear benefits for soil health. Even genetically modified crops could in my opinion under the correct circumstances be accepted as a useful tool to achieve sustainability.

How sustainable farming methods may lead to better self-sufficiency may require a few words of clarification. Such methods, as shown later, produce nutritionally rich food. If better quality food is produced, people will need to eat less to achieve their daily allowances of nutrients putting less strain on the planet's finite resources.

Nutritionally rich food is proven to store better. Longer storage capacity will reduce waste significantly. And lastly, and arguably the most striking claim, sustainable methods of farming can produce better yields and reduce the risk of pest and disease damage.

Food produced in the UK is more likely to reach our plates fresher and therefore with a higher level of nutrient retainment. Eating in tandem with the seasons would not only ease the supply and demand dilemma, but it has shown to offer clear health benefits.

These changes like my proposition to cut the correlation between yield and price cannot and should not be implemented in a short period of time. Everybody would need the right time to plan and prepare ahead.

I readily acknowledge that they are ambitious and radical suggestions, but I already sense that consumers and farmers alike are more willing to consider such changes.

We can and should improve self-sufficiency and food quality at the same time.

CASE STUDY 4

Sonnewald Natural Foods – 'Good health comes from the Farm, not the Pharmacy' – that's the motto of Sonnewald Natural Foods Store owners, Bill and Willa Kiser.

The business started back in 1955 after the release of Harold Lefever , Willa's father, from jail. Harold had spent time as a pacifist, following his refusal to complete a confidential engineering task which he suspected was part of a bomb development project.

Harold pioneered organic farming and began grinding grain for neighbours. Over 50 years on, and the same family runs an 8,000 square feet independent store on the outskirts of York, Pennsylvania.

As far as eating goes, "we don't know how to live, just to die" claimed Willa. Her mission is to inspire, encourage and educate customers to greater levels of health and awareness.

Visiting Sonnewald gave a valuable insight to the role retail has to play in improving our relationship with food. The lay-out of the store was unique, and had been developed to provide as much information as possible to the consumer.

The business engaged their customers on many levels. In the middle of the shop floor stood a counter manned by a specialist member of staff ready to answer questions on a range of health issues. Rather than recommend drugs or offer a prescription, these specialists would guide customers to food items that would help them recover or heal from their condition.

Seminars, lectures and workshops were held on regular basis, and points of display material provided additional nutritional information on all their stocked products. This retailer took great care and effort to ensure the consumer received the best quality information.

The 2 nights I spent with the family at Sonnewald was probably the healthiest 48hours I have ever lived.

SOIL – THE FOUNDATION FOR HEALTHY BODIES

Soil management has to be among the most neglected parts of farming nowadays. Cost cutting, poor subject knowledge and a dependency on bagged fertiliser and pesticides have all contributed to this deterioration. I personally know of some farms that have fields that haven't been soil tested for a number of years, even for pH!

Crops, whether it's grass, cereals or a vegetables will only grow as good as the soil. Readers may interpret my comments and observations over the next few paragraphs as those advocating organic farming. I am neither against nor for organic farming, but I do believe that a common sense approach to sustainable farming should assess all approaches and try to adopt the better ones.

We can all list desirable soil attributes. Ideally, we'd like to have soft soil that crumbles easily, drains well and warms up quickly in spring, does not crust after planting, soaks up heavy rain with little runoff, stores moisture during drought periods, has few clods and no hardpan, resists erosion and nutrient loss, supports high populations of soil organisms, does not require increasing inputs for high yields and above all produces healthy, high-quality crops. Hands up who honestly have soils like this?

Topsoil is the capital reserve of every farm. Ever since mankind started farming, erosion of topsoil has been the single largest threat to a soil's productivity, and consequently to a farm's profitability.

Dr Arden Andersen, one of the world's top consultants on advanced soil and crop management and a practising physician blasted those who gave advice on soil nutrition based on a sheet of chemical results. He carefully described to me that proper soil management also required detailed physical analysis to establish the structure, smell and appearance, and a thorough examination of its historical use.

The type of healthy living soil required to support humans now and far into the future will be balanced in nutrients and high in humus with a diversity of soil organisms. It will produce healthy plants with minimal weed, disease, and insect pressure. To accomplish this, we need to work with natural processes and optimise their functions to sustain our farms.

Ultimately, building organic matter and humus in the soil is a matter of managing the soil's living organisms. Even arable farmers need to re-draft their work description to include animal husbandry, as unless they carefully nurture and rear their herd of soil organisms, their crops will not perform to their best ability.

Whilst at the Rodale Institue, Pennsylvania, Research Manager Dr Paul Hepperly explained to me the role of soil organic matter in holding water, cementing soil particles, reducing acid soil toxicity through natural liming and in increasing micronutrient availability.

One of the best systems I came across in providing practical cost-effective solutions to achieving this was dubbed 'Eco-farming' by the Appropriate Technology Transfer for Rural Areas (ATRRA) project based in Arkansas.

Eco-farming is the system based on the fertility concepts and practices of pioneers William Albrecht, Carey Reams and Phil Callahan. The 3 pillar of eco-farming are as follow:

1. **Mineral Balancing** – This is a system that emphasises base cation saturation ratios (BCSR) and involves supplementing soils with lime and fertilisers to achieve an optimum ratio between calcium and magnesium and so forth. The optimum BCSRs are occasionally known as the Albrecht ratios and in a broader sense it is a key component of eco-farming and may include any form of remineralisation, although natural sources are encouraged before synthetic fertilisers. Simplistic replacement of nitrogen, phosphorous and potassium does not replenish the soil.

2. **Humus Management** – This involves a series of biological farming practices including cover crops, crop rotations, green manures, composting, non-tillage systems, grazing and microbial augmentation to provide food and shelter to living organisms in the soil. Research on life in the soil has determined that there are ideal ratios for certain key organisms in productive soils. All these interact with each other and among the substances they release are vitamins, amino acids, sugars, antibiotics, gums and waxes. Roots can also release into the soil various substances that stimulate soil microbes. Plants can use this means to stimulate the specific population of mirco-organism capable of releasing the nutrients they require. One area of research that should interest all growers is that of mycorrhiza biology, which studies the symbiotic relationship between roots of plants and the mycelium of fungi. There is mounting evidence that these relationships can interact to diffuse weed competition and help the plant to withstand soil diseases and pests. Because we cannot see most of these creatures living in the soil, it is easy to neglect and forget about them, but they are arguably the most important animals on every farm.

3. **Energetics** – This angle of soil management was totally new to me but has since been a cause of fascination. Energetics is a broad term that includes photosynthesis and other natural forces that drive biological systems, as well as subtle energetic influences such as atomic ionisation, background energy in the electro-magnetic spectrum, and biological energy fields at the cellular level.

Unless we get the soil healthy, our chances of producing nutritious food are limited. The longest running US agronomic experiment comparing organic and conventional farming methods based at the Rodale Institute illustrates this.

Not merely a comparison between ideological systems, the Farming System Trial experiment tracks the influence of different soil management techniques. What began in 1981 as a 5-year controlled study of what a typical American grain farmer would go through to give up chemical fertilisers and pesticides has matured into a complex, interdisciplinary, collaborative project that will be continued indefinitely.

The trial compares three strategies, or 'systems,' for grain production: one conventional, one livestock-based organic, and one legume-based organic. The organic standards applied are those advocated by the US Agricultural Department.

Results from the Farming System Trial have been reported in dozens of peer reviewed scientific papers over the years, and include the core finding that corn and soybean yields are the same across the three systems. Although corn yields were about a third lower in the organic systems during the first four years of the study, in subsequent years the organic systems actually outperformed the conventional system under droughty conditions. The portions of the field under conventional management have suffered further degradation from wind and water erosion (when The Rodale Institute purchased the property in the late 1970s it had been used to grow conventional corn continuously for almost two decades), whilst the areas under organic management have shown steady improvements in organic matter, water infiltration, microbial activity, and other soil quality indicators.

The overall benefit of cover-cropping in the organic systems has moved the Institute more towards reduced tillage. Rodale's farm manager summed it up well for me - "In the end it's a combination of methods that seems to work best."

Now entering its 29th year of organic regenerative management, this plot of land is comfortably out performing neighbouring land in terms of yield, nutritional quality and economic performance. To harvest healthy crops, growers need to re-focus on cultivating the soil.

SOLUTION

It's nearly impossible for consumers to distinguish between a nutrient dense tomato and a nutrient poor tomato on shelves. No financial motivation is provided either for producers to increase levels of nutrients in food.

Ironically, livestock farmers take great care when formulating cattle diets for example, taking time to study the nutritional composition details of different feeds and utilising advice from dedicated animal nutritionists. When it comes to shopping in the supermarkets, we scan products based on their appearance and only in some cases do we glance at the basic compositional breakdown of fat, protein and carbohydrate. Surely we humans should also have the opportunity to influence our nutrient intake, just like farmers do for their animals.

During my Nuffield expeditions I came across a solution to this problem, which I would like to present as my main finding and recommendation.

It is possible to measure the nutrient content of food using the Brix Test.

Professor A F W Brix, a 19the century German chemist was the first to measure the density of plant juices by floating a hydrometer in them. At the time, European winemakers were concerned that they could not predict which of the various grape juices would make the best wine. Being able to judge quality ahead of actual bottling was very important when the price differentiation between a poor and excellent bottle of wine could be hundreds. Prof Brix was honoured for developing this simple technique by having the measuring process named after him.

Brix is a measurement of the percent solids in a given weight of plant sap. It includes the content of sugars, vitamins, minerals, amino acids, proteins, hormones and other solids. Brix varies directly with quality. For example, a poor, sour tasting grape from depleted land can test for 8 or less Brix, whereas a full flavoured delicious grape grown on rich fertile land can test for 24 Brix or higher.

Prof Brix's hydrometer was a breakthough, but it was cumbersome and time consuming to use. It also required a significant amount of juice. A simpler easier device was needed.

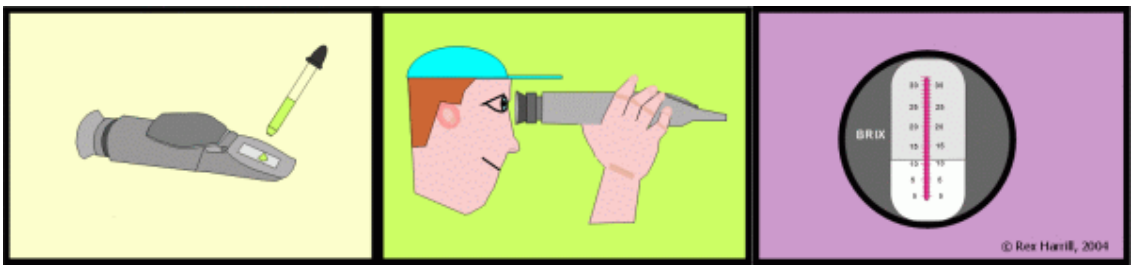
A refractometer is an optical device that uses the fact that light passing through a liquid bends or refracts. This means the denser or thicker the liquid the more it will refract light. Therefore, solids dissolved in a liquid will cause a light beam to exhibit a refractive index (RI) in direct correlation to the amount of solids.

Measurements are usually taken at a reference temperature of 20˚C which is considered to be a typical room reading. Although complicated in construction, a modern hand held refractometer is extremely easy to use and is considered accurate and durable.

Today's refractometer, like the one overleaf, looks like a 15-20cm long telescope, but it has a prism at the opposite end of the viewfinder. A calibrated refractometer allows the user to determine the degree Brix of a crop when a drop of its juice is placed on the prism and flatten with the attached cover plate to ensure that the light travels through a constant depth of juice sample each time.

LEFT: A hand-held refractometer.

The big breakthrough in making Prof Brix's original work accessible came in the early 1970s when Dr Carey Reams walked into the office of ACRES USA (a well respected monthly publication on eco-agriculture) and placed a simple chart on the Editor's desk. The chart correlated Brix numbers with four general (Poor, Average, Good and Excellent, also referred to as PAGE scoring) quality levels for most fruit and vegetables (see appendix 1.) For example, an excellent apple would need a Brix value of 18, whereas potatoes would only require a score of 8 to be classed excellent.



ABOVE: The 3 stages for measuring the Brix content of plant sap.

Dr Reams ran an agricultural consulting company in Orlando from late 1920s until late 1960s when he took up full-time teaching. Servicing the citrus industry, Dr Reams was well aware that citrus crop quality was directly proportional to juice richness. It wasn't until later on he realised that the same concept applied to other crops.

This technique offers a simple solution for consumers to test fresh produce for nutrient content be it produce from the supermarket or their own garden. The same measurement will accurately indicate other useful characteristics that come hand in hand with good quality products.

An excellent rated produce can resist rotting in storage. A high Brix reading indicates dense plant sap which will readily dehydrate as it continues to mature. This will help the plant to store without rotting.

Further Brix based charts have been produced since Reams' original that is still used today as the standard. Another version of Reams' chart compiled together by different American organisations states the Brix reading conferring plant immunity from insect, bacterial, fungal or viral attack. The theory that high Brix scoring plants can withstand these pests has been proven time and again. This chart is called the Reams Composite Chart and can be viewed in Appendix 2.

PAGE standards are likely to change over time as growers succeed to produce ever higher Brix crops. Continuous research may well see the introduction of new revisions of the Reams chart, but Dr

Carey Reams will always be credited with originating and substantiating the Brix equals quality concept.

Consumers would receive more value for money if they bought food with excellent Brix scores. Producers should therefore be awarded for producing nutritionally dense food and consumers need this food to be labelled accordingly.

High Brix scores offer a multitude of benefits for the consumer, the grower and the environment. The system offers a complete package to a grower to brand and promote his or her produce.

Although my main interest was to explore the possibilities of using the Brix model to measure nutrient quality, I was intrigued to find out whether this could be transferred in any way to livestock farming. Welfare, practical and scientific issues made blood testing difficult, but I did find a much simpler method of producing high Brix meat, milk and eggs.

High Brix pasture will nearly without exception produce high Brix livestock products. Some beef farmers, especially those advocating grass based systems have began using high Brix as part of their farming system and to add value to their products.

CASE STUDY 5

Kevin Fulton – Grassfed beef is the ultimate functional food according to Kevin Fulton the Nebraskan cattle farmer and once finalist in the USA strongman competition.

I first met Kevin at a conference set up by the University of Nebraska, Lincoln's extension team. He stood in front of a group of around 50 of us and spoke passionately about his grassfed beef.

It was a rather strange experience for a Welshman to be sitting in the freezing mid West being quoted landmark research work done at IGER Aberystwyth by a Nebraskan farmer who was strongly advocating complete dependency on grass.

Cattle fed with grass (fresh pasture, hay or silage) and kept clear from grains, produced healthier meat and milk. Kevin wasn't the only one to open my eyes to this during my scholarship, especially whilst over in the USA.

Professor Tilak Dhiman of Utah State University provided evidence that grass fed beef not only contained less fat, but a significantly higher percentage of beneficial fats. Grassfed beef has up to 5 times more conjugated linoleic acid (CLA,) 6 times more vitamin E, higher levels of beta carotene, and offers a much better ratio of omega-3 and omega-6 essential fatty acids.

Kevin argued that his beef's enriched nutrient content offered his customers a significant health benefit. He highlighted a recent study in France that pinpointed the role of CLA intake in reducing the risk of breast cancer.

The case for High Brix food using sustainable methods is very convincing. The scope of the challenge in seeking wide scale implementation is immense. It would involve a complete overhaul of how food is produced and priced. Whole supply chains would have to come on board at once.

I admit that this is rather optimistic, so implementation on a smaller scale is most probably the most realistic progress for this concept initially, backed with an intelligent lobbying voice to raise awareness and persuade Governments about the need for change.

At its simplest, the food supply chain is made of a producer, a processor and a retailer, but in reality it is usually far more complicated. The supply chain has to move in synergy to drive this change forward, and voluntary initiatives could be one option but I favour some form of light touch Government intervention that will seek to develop a consensus and work towards co-ordinating a well planned change.

CASE STUDY 6

Beyond Organix – A Californian based company called Beyond Organix is among the first in the world to start classifying their produce according to Brix values. Its owners, Stan Kadota, Arden Andersen, Mark and Ted Nakata, believe that nutrients are assimilated better and gives people better health if contained in biologically complex forms as opposed to artificial supplements.

Beyond Organix acts as an Independent Certification Organisation. Its label, 'BYO,' will appear on fresh products as a stamp of documented provable nutritional value of the product.

The company communicates the extended benefits of high Brix food. As the nutrient value increases, it claims that by default the company addresses the pesticide residue issue, environmental issues, greenhouse gas issues, sustainability of family farms and fair trade matters. All in all, its message is very powerful, but it may possibly confuse the consumer with all the messages. It would be much more effective to maintain focus on the health benefits in my opinion.

BYO stamped products are only available from selected small store chains at the moment due to a limited supply of superior quality products and that smaller chains cater to the more discerning shopper.

Good Brix scores is a win-win situation. Good results awards good soil management and sustainable methods of farming. Pests and diseases are far more likely to attack low Brix plants. High Brix crops will allow retailers to offer customers premium products that will also stay fresher for longer.

According to Beyond Organix, high Brix food will lead to healthier people and a more vibrant economy. I am adamant that the demand for a similar enterprise in the UK exists, but as flagged up by BYO, the supply chain would take considerable time and effort to build up. This is probably an opportunity for a grower to add value rather than a non-farming business to source.

FUNCTIONAL CROPS

Brix could lead to the improvement of food nutrition across the board, but as an agronomist, I was keen to find crops that offer exciting prospects for improving health.

Camelina

Camelina is an oilseed crop commonly grown in Scandinavian countries and Russia. Raisio, the maker of Benecol, acquired a small Finnish University spin-off company named Camelina in 2004 for €1.2m, and has since introduced camelina oil in its range of spreads in order to increase omega-3 and vitamin E levels. Camelina has been successfully grown in the UK, and shows good signs of being able to carve a lucrative niche within the edible oils market.

Camelina is a member of the Brassica family. Sown in mid April and harvested in late August, it suits the climatic conditions found in most parts of the UK. The tiny orange sesame like seed requires quality harvesting machines. Once harvested and dried, the seed can be cold pressed to produce one of the best sources of vegetative omega-3 essential fatty acids. The oil is mellow and sufficiently stable to cook with. Other than for my own company, Calon Lân Food, I am not aware of any other company selling cold-pressed extra virgin camelina oil in the UK, but its characteristics and ease of cultivation should offer exciting commercial opportunities for the future.

Mintel's report on Edible Oils in December 2007 forecasts market growth to 2012 at 49% to reach total value of £411m. The report identified consumer health concerns as the biggest driver in the novel oilseed sector, with growth in speciality oils driven by perceived health benefits. It also highlighted that crops grown in the UK could gain a higher profile as consumers take their Carbon footprint into consideration when buying food.

CASE STUDY 7

Omega Moment – Many of us know what we are supposed to eat and what not to, but we don't necessarily know why. I knew that omega-3 was lacking in our diet but I was never able to explain why.

Then I met Prof Katherine Sherif from Drexel University College of Medicine, Philadelphia at the Farming for the Future Conference, Pennsylvania.

She reminded me that each human cell is surrounded by a wall that is essentially made out of protein and fat. The fat element is mostly made from a combination of omega-3 and omega-6 essential fatty acids.

If these molecules were rugby players she said, omega-3 would be fast moving quick footed wingers, and omega-6 would be the heavy rigid props. Because of these characteristics, the ability of cells to filter in food and excrete waste depends on the proportion of omega-3 and omega-6 in the cell wall. If our diet has sufficient omega-3, our cell walls will be more populated with nifty wingers that will

allow a free and efficient transfer of waste and food into and out of cells. Too many omega-6 will hamper the movement of waste and food, triggering multiple system failures across the body's function.

It was worth visiting Pennsylvania just to hear this simple explanation.

Oats

Along with wheat and barley, oats is one of the most common cereals grown in the UK and needs little introduction.

During the course of studying functional food it became clearer to me that not only can oats be grown in several parts of the UK, but it also offers universally accepted health benefits. During the lifetime of the Joint Health Claims Initiative, there were only 5 claims accepted for general use. One of these referred to the consumption of oats and read as follow:

"The inclusion of oats as part of a diet low in saturated fat and a healthy lifestyle can help reduce blood cholesterol."

Oats contains more soluble fibre than any other grain, resulting in slower digestion and an extended sensation of fullness. One type of soluble fibre found in oats, beta-glucans, has been found to help lower cholesterol.

To monitor the claim, the JHCI stipulated that beta-glucan fibre was to serve as a marker for the oat product. For example, it noted that oat bran provided 5.5% beta glucan soluble fibre, and that each recommended serving must include 0.75g of it.

Oat based products, and oat ingredients peaked in their popularity in the USA in the late 1980s, but faded away in the following years. I am concerned for the tendency of functional food to be short-lived fads.

Fortunately, oats reclaimed lost ground by the end of 1990s after the American Food Standards Agency re-confirmed oats status as a healthy ingredient. It appears that without Government recognition which will only come on the back of sound scientific evidence, there is always a risk that functional foods can become fads rather than a long-term eating trend.

Further research highlighted that naked oat varieties, or hulless oats contained even higher content of beta-glucan than conventional varieties. Contracts are widely available for producing oats, but it may also open the door for some growers to consider ways of processing their own oat product to benefit from oats' healthy public image.

Within the novel cereals sector, forecasted growth by HGCA (2008) was highest for speciality flour which includes various types made out of novel cereals, offering the consumer a new cooking experience. The demand for healthy products, the strong upward trend for speciality flours and the

increasing importance of food provenance highlights the market opportunity for novel cereal growers in the UK.

Beetroot

It has always struck me as peculiar how hundreds of acres of perfectly edible swedes and turnips are grown in north Wales every year for sheep whilst at the same time local shops, restaurant and hotels are craving for locally grown root crops.

I know there are probably sound economical reasons in terms of labour costs and seasonal logistics, but it does highlight the UK's ability to grow quality root crops.

I was intrigued during my travels to read about beetroot's elevation to superfood status in the printed media on the back of recent research and clever marketing.

Its Britishness and seasonality has also caught chef's imagination, as new recipes and uses have sprouted for the vegetable from grated on salads to accompanying cheese on toast.

Its health credentials however are impressive. Beetroot's high folic acid content has made it a popular choice among pregnant women and those planning to become pregnant. Other features include a high magnesium and potassium content and similarly to oats, beetroot is rich in soluble fibre.

Beetroot sales has increased in the UK over the last 5 years, and is set to grow over the next 5 years.

Grass

It takes a brave Welshman to confess to having been taught about the virtues of grass in Nebraska. This was indeed my experience whilst attending the 'Profitable and Sustainable Agricultural Opportunities in Nebraska' conference.

I did not expect to have grass on my list of functional crops, but having learnt about its key benefits in improving the nutritional quality of animal products, as illustrated in Kevin Fulton's case study, I am convinced that British grassland farmers or not fully utilising its potential.

A high Brix grass sward can adequately feed a steer or lamb without the need for expensive supplements, but it's a cause of real frustration that we are missing an opportunity to strengthen our core agricultural products with a crop we already successfully grow in all parts of the UK. Because of this, grass appears later on in the report as one of the main commercial opportunities I saw during my travels.

Wheatgrass

Back at the start of the report, I explained that food becomes functional when a customer's purchase is stimulated by a perception it will improve their health. The actual reality in some case can be vague.

Wheatgrass is one such example. I have noticed a surge in the demand for wheatgrass juice. Wheatgrass refers to the young grass of a wheat plant, which is freshly juiced 7 to 10 days after germination.

There is no proven evidence to show its health benefits, but advocates believe that the high chlorophyll content can help bloodflow and digestion. Consumers of wheatgrass juice also believe it can help to detoxify.

With small shots of fresh wheatgrass juice retailing at £2, there is a potential lucrative return to be made, but there is little market intelligence available due to the fragmented nature of the outlets.

Claims have also been made about the high enzymatic activity of newly sprouted plants in general. Natural food stores are a rapidly growing sector of the food retail industry in America, where sprouted plants can be bought in ready to eat format. Although such products have been tried in the UK, none appear to have established itself as a market leader, possibly due to its very short shelf life.

Sprouts and wheatgrass can be processed to powder form for better storage.

OPPORTUNITIES

I had been forewarned before embarking on my trips that I may suffer from over indulgence in new business opportunities. I truly believe that travelling is the best way to discover new ideas. As one successful Munich business man told me, his R&D department spends the most of their budget on travelling. For him R&D stood for **R**epeating successful ideas and **D**uplicating them elsewhere.

1. **Grass fed ruminants** – As featured in one of my case studies, Kevin Fulton is one of a growing number of advocates of grassfed beef in the USA. There is ample evidence to show the benefits of consuming grassfed beef.

   Adding value to beef and lamb is an on-going challenge on British farms, but there are only a very small number of businesses who I'm aware that properly promote the benefits of grass fed livestock. Unlike Kevin and his fellow Nebraskans, we probably take grass for granted without realising its virtues.

   I'm convinced that there is a gap in the market for beef and lamb producers to work together on developing a grass based feeding protocol to produce quality meat. It has all the attributes of a successful product.

   Grass is rightly perceived as clean and natural. Top US chefs are ready to swear by its superior taste, and above all it delivers clear nutritional benefits for the consumer.

2. **Brix food** – Consumers like choice. Choosing nutritionally dense food is a lottery at the moment, as there are no accreditation offered to producers to differentiate between low nutrient and high nutrients food.

   The Brix method as described in this report offers a method to check and assure consumers of the quality of fresh produce. The challenges and threats of such a development have been outlined, but the potential upturn for a fledgling company to lead in a knowledge based sector is significant. The Brix concept is simple to understand and provides customers with information they want.

   With health being one of the main market drivers in the grocery market, consumers are willing to pay more for healthier produce.

3. **'Farmacy' retailing** – Britain has a greater tendency to follow its cross Atlantic partner more than its European counterpart. For this reason I was interested to find out the latest trend in food retailing over in the USA.

   I visited 3 separate stores during my time there that had a clear emphasis on offering healthy food options to its customers. Each business felt their responsibility went further than just providing a selection of items for customers to browse through. Instead they had a mission statement to inform customers of how to follow a healthy and wholesome diet.

   The stores' level of interactivity was exceptionally high, with many features that I had not come across before such as a bulk buying room where seeds, pulses, pasta, rice and fruits

could be bought in bulk from bins, just like a adult version of pic'n'mix. Customers could mill their own grain and press their own seed to produce oil.

Each store had a sizable healthy take-away offering which enabled the business to attract useful footfall and extend the opening hours.

These businesses were geared up to provide customers with ideas, guidance and advice when called upon. At least one member of staff on duty was a qualified nutritionist who was able to provide answers to customers' questions.

American towns like British towns has suffered the negative effects of large supermarkets, but it may have started earlier in the USA. It's interesting to note the growth of natural food stores across America as a possible future opportunity for British retailers, or have Farm Shops already filled that gap?

CONCLUSIONS AND RECOMMENDATIONS

I realised during my travels that my perception of functional food was far too narrow and naive. I saw it as a commercial opportunity for food producers to add further value to their food.

Since visiting several countries and meeting a large number of inspirational people, my exploration has uncovered a more fundamental issue in relation to food nutrition, and that's the deterioration of the basic functionality of food. Does it make sense to try and conjure functionally advanced food items to add value whilst the bulk of food was going the other direction? Indeed, is it ethical?

It's was this dilemma that I had to face. Ethically, I concluded that modern day functional foods is acceptable as long as we accept that different communities will always be at a different stage of the food evolution journey. A far more fundamental question about food ethics is having obscene food waste in one country, whereas the people of another dies in hunger.

I couldn't however feel satisfied that it made sense to ignore the basic deterioration of nutrient content in food whilst focusing on a premium niche of nutritionally charged food. For this reason I allowed my Nuffield experience to slightly divert from the original brief as I knew that the majority of people in the agri-food industry would want me to do that.

No one can be happy with the situation We have the technology to produce nutritious food but we lack the economic impetus.

Plants have given us some of the most wonderful materials for healing, building and eating, and yet we choose to ignore their ability to feed us, be that directly or indirectly through animal products. The solutions given in this report could not only vastly improve our health but could simultaneously direct farming towards sustainable principles of cultivating the soil and harvesting crops.

Functional food is all about improving human health. It offers agriculture a significant commercial opportunity and a chance to improve the image of farming. Agriculture needs to invest time and capital in developing this knowledge based industry, especially in light of increasing competition for commodities from across the globe.

The thrust of my report is about a changing mindset. Once this is achieved, the exact methodology of how to progress will become clearer. I have already alluded to some of the required fundamental changes in land management. We need a food production system to adequately nourish people, not just filling them up.

Accepting this, the next question is how do we start the ball rolling? My list of recommendations provides 10 steps that would need to be implemented to get us on the road to recovery.

1. Firstly the industry needs to accept the issue before anything can happen. This can be a collective effort but would probably need a leading party. I feel that the farming Unions are well positioned to do take on this role in a sensitive and structured manner, but I also realistically accept that they may not consider this as their priority or even their function.

Alternatively a grassroot revolution is required, but this could take years and would probably act in a fragmented fashion making it easy for those who wish to dismiss these facts to do so. As a long-term solution I strongly advocate the establishment of a body to provide leadership and co-ordination on behalf of the Government and industry. The closest similarity I can make is with the National Non-Food Crop Centre that was established in 2003 to drive forward the use of plant derived renewable material for non-food applications. Its success has been impressive. We need a 'Centre for Better Food Nutrition' in the UK. Its initial cost would soon be recuperated by less waste, better farming and a healthier population.

2. Closely following a general acceptance of the issue would be a fundamental overhaul of agri-food R&D priorities in the UK. Institutions geared towards driving yields skyward would need to quickly address their strategies to provide the necessary support and knowledge for a new food production model.

3. The agri-food industry is made up of a large number of sub-sectors intertwined in a complex chain. I am concerned that some areas of the supply chain would react more swiftly than others. In preparation for possible resistance, the Government should publish clear guidelines, possible through the newly established Centre, right at the start. This document should outline the Government's willingness to consider light touch legislation to push forward with changes if necessary.

4. Agricultural education establishment need to revise their courses accordingly. Some of the most striking changes would include the need to teach the link between soil health, plant health and people's health, and the re-introduction of soil science as a core principle across the whole spectrum of agriculture. It is not the role of educational establishment to advocate one system over another, but I do feel that the current provisions do not allow enough freedom for lecturers and hence students to explore alternative production systems and their implications on people's health.

5. Changing the pricing mechanism for food would bring in sweeping changes. Due to the gravity of the change, I believe a thorough examination would be required to understand the likely consequences of introducing a system whereby farmers would be given a price calculated on nutrient content rather than pure weight yield. This should minimise disruption and increase the probability of using the right methods.

6. In the same way, introducing new information on food labels require careful planning and consideration to ensure that the aims are met. Despite the sense of urgency I feel with implementing these changes, they must be done properly. I would much prefer a successful outcome on the back of 5 years of detailed research and planning as opposed to a botch job on the back of rushed through initiatives.

7. Agriculture and food need to be closer aligned, especially in the public sector. What one sector does has an effect on the other. I would welcome a similar relationship between agri-food and health departments. The link between farming, food and health needs to be reflected in all Governmental structures.

8. The Food Standards Agency has to ensure a smooth and effective implementation of the new EU regulation on nutrition and health claims on food. Having a robust structure in place to protect the integrity of the industry is essential, but at the same time the FSA has the task of ensuring a clear path for companies to innovate new products with minimal bureaucratic hurdles.

9. The agri-food industry today is global. Realistically, a thorough pan industry change in the UK will be impossible without the support of foreign businesses and Government. Ideally, any changes made in the UK would be welcomed and replicated abroad in other developed countries. I would recommend that the UK embarks on a mission to work with its international partners such as the EU, the United Nations' FAO, and the WTO to develop a new system of rewarding food producers for nutrition rather than just yields. From my travels, I would expect that other countries, such as Japan would be able to provide the UK with support and useful experience. I recognise that many countries struggle to even feed their people, but this report focuses on progressing food to nourish in developed countries, not developing countries. Governments can adequately tackle both agendas.

10. It's very easy to pass responsibility on to other people or the Government. I want my tenth key recommendation to remind us all that we must act on what knowledge we have. We all know that eating too much is bad, but the majority of us are guilty of doing it to some level. As practitioners in agriculture and consumers of food, it's our responsibility to act on the knowledge we have. If you continue to be sceptical of any part of my report, then please do further research on your own and I am confident that any conclusion you come to will not be far off, if at all, from mine.

HOW MY NUFFIELD SCHOLARSHIP HAS INFLUENCED MY 'OCCUPASSION'

Despite the worries of having to abandon my young consultancy company Madryn Ltd on more than one occasion in 2006-07, the time I spent away provided me with the opportunity to plan out my course upon my return.

Having accepted the need to be in a position to influence the whole supply chain to develop functional foods, I have since launched a range of products under the Calon Lân brand. Calon Lân is the first UK company to sell cold-pressed camelina oil, and runs what is possibly the northern most olive grove in Europe on Anglesey.

In June 2007, I took the gamble of not only going into partnership with my brothers, but also to buy a local delicatessen with them, despite Asda having opened their doors in town 6 months earlier. 12 months on, and we opened our second outlet in Porthmadog.

I have succeeded in having a business interest across the supply chain, from working with growers to processing to retailing. Thank you Nuffield for giving me the necessary push.

10 USEFUL WEBSITES

The World Wide Web has made information accessible on all kinds of subject matter. It is partly for this reason that I have spent more time and effort in communicating my experiences and opinions in this report, as otherwise a report providing just facts and figures would provide nothing more than what a few sessions of web surfing could carve out.

As with all topics, the quality of online content varies considerably. Because I spent time exploring the net, I thought a top 10 list of the most useful websites that I came across would be of interest to you the reader. Take it as a slightly more refined and reviewed form of a Google search result.

Website address	Note
www.ifr.ac.uk	Institute of Food Research
www.bleu-blanc-coeur.com/	Bleu Blanc Coeur – see Case Study 1
www.igd.com	Registered charity consisting of experts dedicated to the development of the food and grocery industry.
www.foodchaincentre.com	Free support service for British food producers.
www.westonaprice.org	Charity set up to disseminate the research of nutrition pioneer Dr Weston A Price.
http://www.umanitoba.ca/research/rcffn/	Richardson Centre for Functional Food and Nutraceuticals, University of Manitoba, Canada. The only dedicated academic centre researching functional food that I'm aware of.
http://ec.europa.eu/food/food/labellingnutrition/claims/index_en.htm	Current information on EU rules governing Health Claims on food products.
www.sonnewald.org	The future of ethical retailing possibly.
www.rodaleinstitute.org	Official website for the Rodale Institute.
www.calonlanfood.com	First UK company to sell British extra virgin camelina oil.

APPENDIX 1 – Reams Chart

Refractive Index of crop juices – calibrated in degree Brix

CROP	Poor	Average	Good	Excellent
Apples	6	10	14	18
Asparagus	2	4	6	8
Avocados	4	6	8	10
Bananas	8	10	12	14
Broccoli	6	8	10	12
Cabbage	6	8	10	12
Carrots	4	8	14	18
Cauliflower	4	6	8	10
Grains	6	10	14	18
Grapes	8	12	16	20
Green Beans	4	6	8	10
Lemons	4	6	8	10
Lettuce	4	6	8	10
Onions	4	6	8	10
Oranges	6	10	16	20
Pears	6	10	12	14
Potatoes	3	5	7	9
Raisins	60	70	75	80
Raspberries	6	8	12	14
Squashes	6	8	12	14
Strawberries	6	10	14	16
Sweetcorn	6	10	18	24
Sweet Potatoes	6	8	10	14
Tomatoes	4	6	8	12
Turnips	4	6	8	10

APPENDIX 2 – Reams Composite Chart

Refractive Index of crop juices – calibrated in degree Brix

CROP	Poor	Average	Good	Excellent	Disease Free
Apples	6	10	14	18	16
Green Beans	4	6	8	14	14
Lettuce	4	6	8	12	12
Potatoes	3			13	13
Raspberries	6	8	12	14	15
Squashes	6	8	12	14	15
Strawberries	6	10	14	16	16
Sweetcorn	6	10	18	24	24
Tomatoes	4	6	8	12	18