



**A Nuffield Farming Scholarships Trust
Report**

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**Vegetable production for
specific nutritional need**

Barbara Bray

July 2018

NUFFIELD

This report is written for plant breeders, vegetable growers, manufacturers of prepared vegetable products, manufacturers of specialist meals, nutritionists and dietitians, plant scientists, retailers, food marketers, policy makers and public health professionals

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ISBN: 978-1-912059-90-4

Published by The Nuffield Farming Scholarships Trust

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Nuffield (UK) Farming Scholarships Trust Report



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Inspiring passion and potential in
people."*

| | |
|--------------------------|--|
| Title | Vegetable production for specific nutritional need |
| Scholar | Barbara Bray |
| Sponsor | The Food Chain |
| Objectives of Study Tour | <ul style="list-style-type: none">• investigate how consumption of vegetables can meet specific nutritional needs• to report on the dietary guidelines, policies and activities for promoting the consumption of vegetables in different countries• compare international and UK guidelines and attempt to answer the question whether government led, or producer led initiatives are more effective along with recommendations for the future• conduct a case study in conjunction with the University of Reading to look at how nutritional guidelines for a population group can be used by the food industry to formulate targeted products for people with chronic kidney disease |
| Countries Visited | USA, Ireland, Germany, China, South Korea, New Zealand |
| Messages | <ul style="list-style-type: none">• Multidisciplinary working is needed to achieve a food system with nutrition smart outcomes.• The prepared produce industry should work with the supply chain to deliver a solution to communicate potassium levels on food products.• Convenient meal solutions and clear communication of benefits to the consumer are needed in the vegetable sector.• The health and nutrition claim regulations should be adapted for the fresh produce sector if the UK exits the EU. |

Executive Summary

As a nation, there is more food available to us than in previous generations, but this has caused a triple burden of malnutrition where overeating and undernutrition co-exist, and 'hidden hunger' where the excess calories consumed do not provide the optimum nutrients for health. In the UK the lack of key nutrients such as fibre, vitamin A and folate in many diets can be directly linked to the low consumption of vegetables.

My primary aim was to investigate the specific nutritional needs and dietary concerns in the countries I visited and assess how vegetables can meet these needs in those countries. I then selected three of these countries and report on their dietary guidelines, policies and activities for promoting the consumption of vegetables. I wanted to understand what networks exist to bring different parts of the food system together to work on health enhancement projects.

My other key aim was to study if, or how, the food system is targeting specific groups for health needs and personalised nutrition. I have used the example of potassium levels in potato products for a specific health need as a case study for multi-disciplinary working.

My findings show that multi-disciplinary working throughout the food system is needed if we are to achieve a food system that can deliver nutritious, safe, affordable food that has been produced in a sustainable way. Breeders and growers have the knowledge and expertise to improve the nutritive value of our crops but need to work with the food supply chain to get these foods into institutions, the food service sector, as well as retail. The practise of 'nutrition smart agriculture' needs to be supported across the food chain so that higher nutrition crops can be grown whilst also enabling farmers to improve production as well as make a profit.

From the case study, retailers, nutrition scientists and growers should look at the benefits of quantifying levels of potassium, in raw produce or cooked, prepared foods. A sampling programme to validate the levels, followed by a regular verification programme, should be drawn up and the results rolled out into an online databank for suppliers, retailers and consumers.

In summary, the UK Government needs to look at nutrition as integral to policies across education, health and social care, agriculture and industry, and use all available resources to improve the national diet. If the UK leaves the EU there will also be an opportunity to modify existing nutrition and health claim regulations to tailor them for use by the fresh produce sector to help suppliers and producers meet these needs.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor The Food Chain, or of any other sponsoring body.

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Published by The Nuffield Farming Scholarships Trust
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1. Personal Introduction

I grew up in 1970s County Durham, an area with a history of heavy industry, agriculture and stunning landscapes. My parents had moved there a few years after completing their studies in Edinburgh as new immigrants to the UK. They chose a great location for my sisters and I to grow up in, and when I left home at the age of 18 to read for my first degree in Food Technology at the University of Reading, it surprised me how different life is in the South of England compared to the North.

Since my first international trip, aged 17, with the Guiding Association to Thailand, I have loved to travel and learn about the people, the food they eat and where it comes from.

My early career was spent with a farming NGO in Uganda, then a commercial farm, before returning to the UK to work for an international chilled foods manufacturer for 14 years. I then set up my food safety and nutrition consultancy business, Alo Solutions Ltd. in 2014.

I enjoy getting things done, so not content with having set up a new business I continued volunteering for “Tough Mudder”, “Leeds Big Bookend” reading festival and ran the Nutrition Society Student conference at the University of Chester in 2016. I organise professional workshops for SENSE nutritionists, an organisation which provides professional development, learning opportunities and support for self-employed nutritionists. I am a committee member of the Institute of Food Science and Technology (IFST) Food and Nutrition group and a member of the Nutrition Society’s training and development committee, NSTA. I enjoy speaking at university events about food and nutrition and can be frequently found contributing to debates on social media about food.

I now live in Manchester, the centre of the Northern Powerhouse and home to a wide range of different ethnicities, cultures and food, all united by a love of either Manchester United or Manchester City football clubs. When I am not working with food I spend time with my family, or indulging in my new favourite pastime, open water swimming.



Figure 1. Author Barbara Bray



2. Introduction

In the UK approximately 30% of the population is overweight and another 30% is obese (Public Health England, 2017). This is largely due to eating too much and exercising too little. Yet despite consuming these excessive calories, we are still not well nourished because we do not consume sufficient fruit and vegetables to maintain optimum health. Furthermore, 10% of children in the UK are reported to live in severe food insecurity (The Food Foundation, 2017). This situation of under and overnutrition combined with a lack of nourishment is referred to by the Food and Agriculture Organisation (FAO) as the “Triple Burden of Malnutrition”.

There are many reasons why we do not achieve the recommended 5 portions of fruit and vegetables a day, these include affordability, accessibility, convenience, physical health impairments, and diet related conditions. The latest results of the National Diet and Nutrition Survey (NDNS), a rolling cross-sectional survey of food consumption and nutrient intake of the general population, show that fruit and vegetable consumption is in slight decline.

Steps are being taken by Public Health England (PHE) to improve the nation's diet; however, PHE has been accused of being a ‘Nanny State’ by telling people what to eat, but with the current health crises and a food system that cannot provide safe, nutritious and affordable food to everyone, changes are needed.

Achieving a balanced diet in the context of environmentally sustainable food production is also a challenge. To help address this, the World Wildlife Fund (WWF), an independent conservation organisation, has produced guides focused on age groups, gender and dietary preferences (WWF, 2017). The example shown in Figure 2 recommends a target of 432g of fruit and vegetables per adult per day by 2030, compared to the current 400g recommended by the PHE Eatwell Guide.

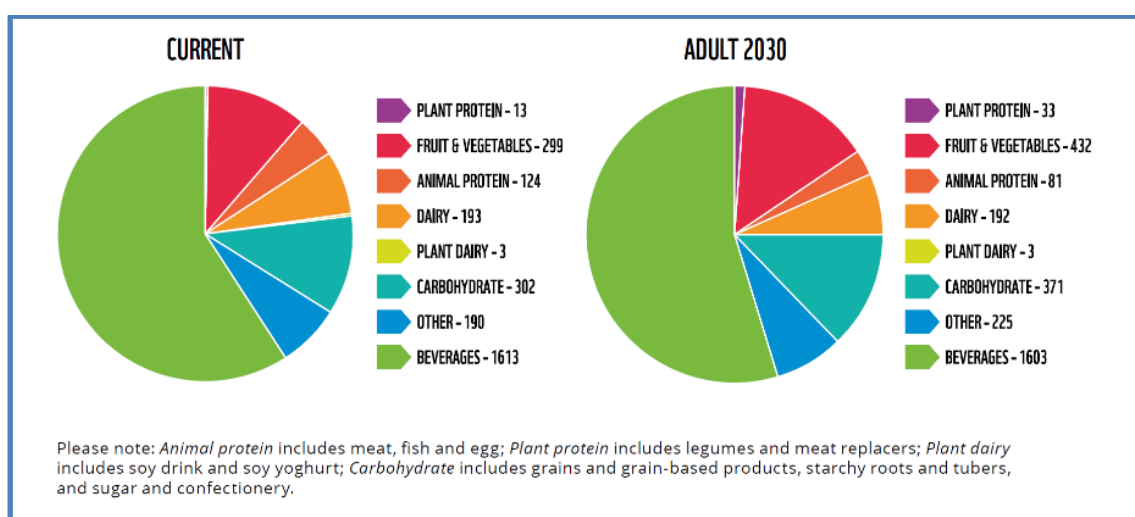


Figure 2. WWF table showing the current recommended average composition (grams) of the adult diet in the UK (left) [‘The Eatwell Guide’ (PHE)]; and the recommended composition by 2030 (right) [‘The Livewell Plate’ 2030 (WWF)].



The food system is an integral part of our lives. It is the path that food travels from field to fork, including growing, processing, packaging, transporting, marketing and consuming of food. How it is grown is important to ensure that it not only delivers nutritious and safe food but is sustainable enough to feed the future population.

The pre-study research that I carried out highlighted the complex nature of recommending the best diet to different population groups. Food is eaten not just as a fuel but involves cultural preferences, beliefs, social occasions and restricted choices due to physical or mental health. This complexity has yet another facet as modern food production has prioritised cost efficiency, yield and disease resistance which leaves little room for nutritional health.

Commercial farming is the source of most of our food and yet the link between food production and health is not a strong one. Therefore, my report looks at where the links can be better exploited within the vegetable sector.



3. My study tour

The focus of my Nuffield Farming Scholarship personal study tour was to investigate how vegetables can meet specific nutritional needs and to report on the dietary guidelines, policies and activities for promoting the consumption of vegetables in different countries. I then compare those with practices in the UK and attempt to answer the question whether government-led, or producer-led initiatives are more effective and suggest recommendations for the future.

With my increasing interest in nutrition for specific needs, I carried out a case study in conjunction with the University of Reading to investigate potassium levels in potatoes. I looked at how nutritional guidelines in different countries might be used by the food industry to formulate targeted products for specific population groups. I used chronic kidney disease (CKD) as an example. I investigated the following five key questions:

1. What networks currently exist to bring nutritionists, dietitians, growers, manufacturers and research scientists together to work on health enhancement projects?
2. What research is there into the use of biofortification and enhanced vegetables to solve human nutrition problems?
3. What information exists on the potassium content of different varieties of potatoes, especially those grown in the UK?
4. What options exist to indicate potassium levels on the labels of processed products in different countries?
5. What products can be manufactured from potato that would sit in the 'safe range' for CKD sufferers

I started my Nuffield study in the UK, attending meetings and events and speaking with stakeholders across different parts of the food supply chain and healthcare sector.

This was followed by the Global Focus Programme trip I took in May 2017 to Singapore, Indonesia, Japan, Israel, UK and USA. The Nuffield triennial conference 'Farming Fit for Food' was ideally timed for me to hear from speakers including the nutrition scientist Professor Susan Jebb and the farmer and rapeseed oil producer Duncan Farrington.

The focus of my Nuffield Farming Scholarship study tour was my trip to China, South Korea and New Zealand in September, October and November 2017. The countries in the Australasian region were of great interest from food production, food processing and health perspectives. A visit to the Asiafruit congress 2017 in Hong Kong, kindly sponsored by Fruitnet Media, was a good opportunity to meet key horticultural producers from the region and gather a list of people and organisations to contact in Shanghai, South Korea and New Zealand. The locations are highlighted on the map below.

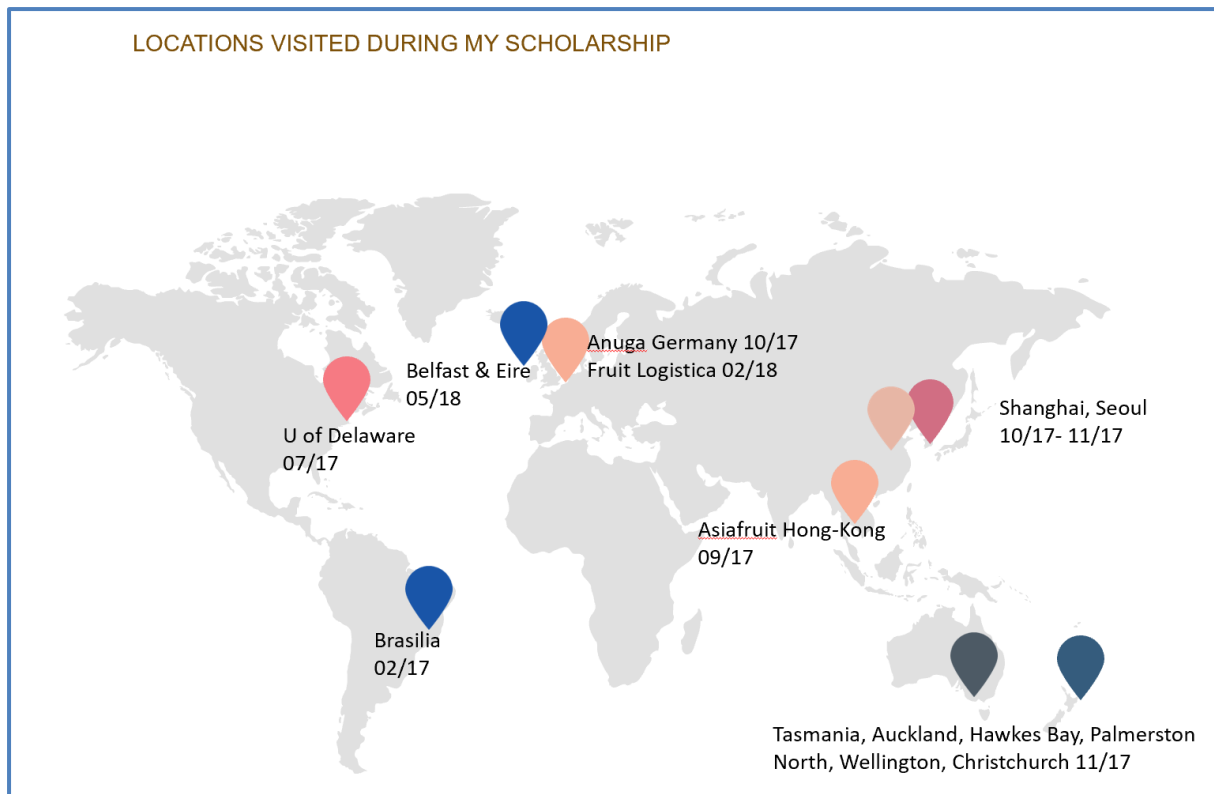


Figure 3. Locations visited for research during my Nuffield Farming Scholarship study tour

These locations were selected because of their diverse cultural, political and economic backgrounds. My interest was in the roles of manufacturers, producers, retailers, and the food-service sectors, either individually or in collaboration with other researchers and public health institutions.

I also benefited from visits to government departments and attended conferences, exhibitions and trade fairs in the USA, Germany, Ireland and throughout the U.K.



4. Vegetable consumption and healthy eating policies

4.1. Overview

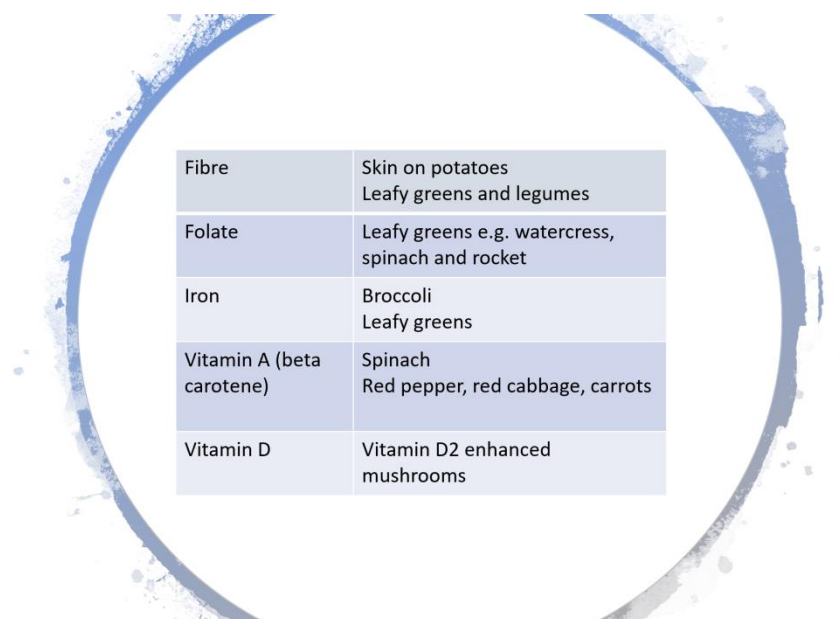
A diet rich in a variety of vegetables and fruits is essential for health and wellbeing. This chapter reports how government policies worldwide are structured to support this.

The World Health Organisation and United Nations Food and Agriculture Organisation expert committee (WHO/FAO) set recommendations in 2003 for increased consumptions of wholegrain cereals, legumes, fruits and vegetables for their potential health benefits against a variety of conditions including the prevention of obesity, diabetes, cardiovascular disease and certain types of cancers (PHE, 2018).

The World Cancer Research Fund (WCRF) recommends eating vegetables and fruits to reduce the risk of developing cancers such as mouth, throat and lung cancers (WCRF, 2018). Vegetables and fruit provide vitamins, minerals and phytochemical compounds that help protect the cells in the body from damage that could lead to cancer.

Different vegetables contain different essential nutrients (examples shown in Figure 4); therefore it's important to eat a wide variety of vegetables to get the best benefits.

[See Appendix 1: 'The Power of Vegetables' for details of how these nutrients work in the human body.]



| | |
|------------------------------|---|
| Fibre | Skin on potatoes Leafy greens and legumes |
| Folate | Leafy greens e.g. watercress, spinach and rocket |
| Iron | Broccoli Leafy greens |
| Vitamin A (beta carotene) | Spinach Red pepper, red cabbage, carrots |
| Vitamin D | Vitamin D2 enhanced mushrooms |

Figure 4. Examples of nutrients found in vegetables.

Yet, despite various public health campaigns over many years, the intake of vegetables and fruits remains below recommended levels for a large proportion of most populations, while rates of obesity and associated diseases, such as type 2 diabetes and chronic heart disease, are increasing. These trends appear to be irrespective of cultural, economic or religious differences.



4.2. National dietary guidelines and initiatives in the UK

PHE sets government guidelines for healthy eating in the UK and introduced the 'Eatwell Guide' in 2016 (Figure 5) to replace the 'Eatwell Plate'. This was designed as a policy tool to define and promote government recommendations for a healthy, balanced diet.

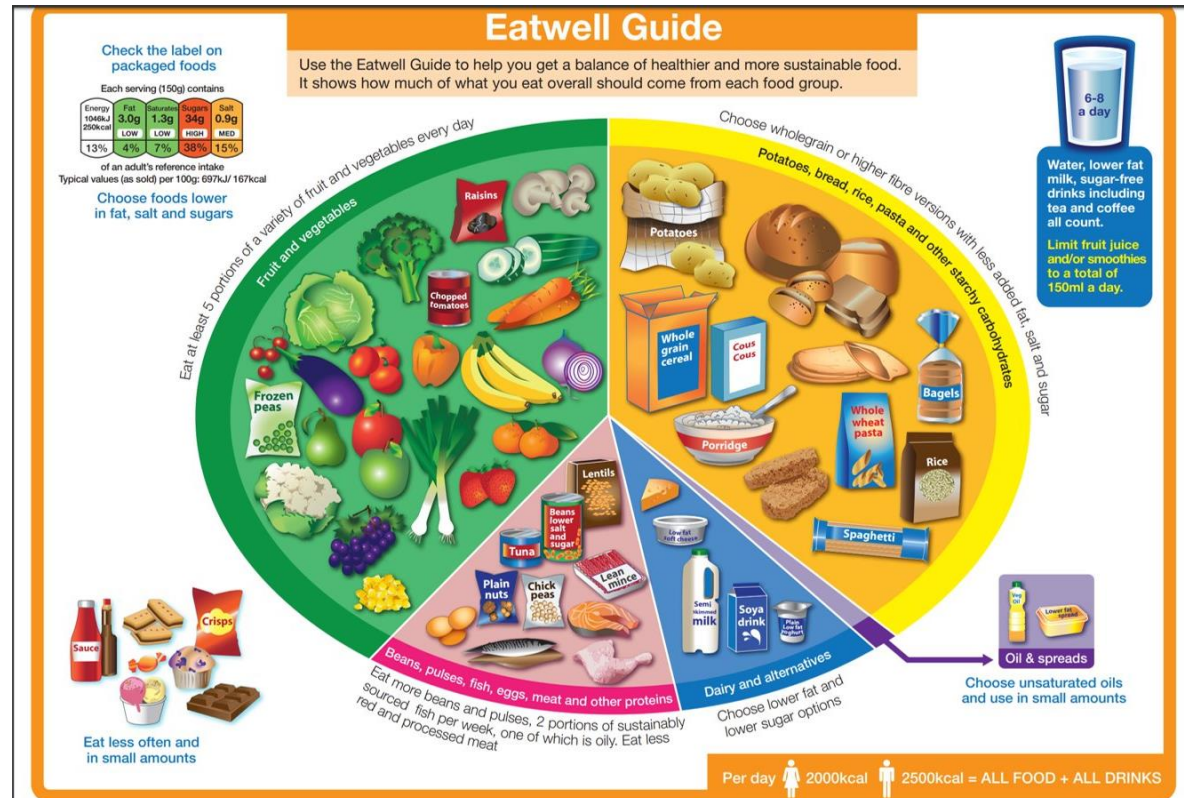


Figure 5. The Eatwell Guide 2016 (PHE), showing the recommended balance of foods in the fruit and vegetable, animal and plant protein, dairy and starchy carbohydrate categories

Nutrition surveys for different population groups in the UK are carried out by the NDNS (Figure 6). These reveal a continuing decline in fruit and vegetable consumption, along with increasing obesity figures, especially among children. As a result, PHE has introduced new interventions to improve our diets: (a) the sugar-sweetened beverages tax which came into force in 2018; and (b) a target for food manufacturers and caterers to cut 20% of calories from a list of foods by 2024 (PHE, 2018).

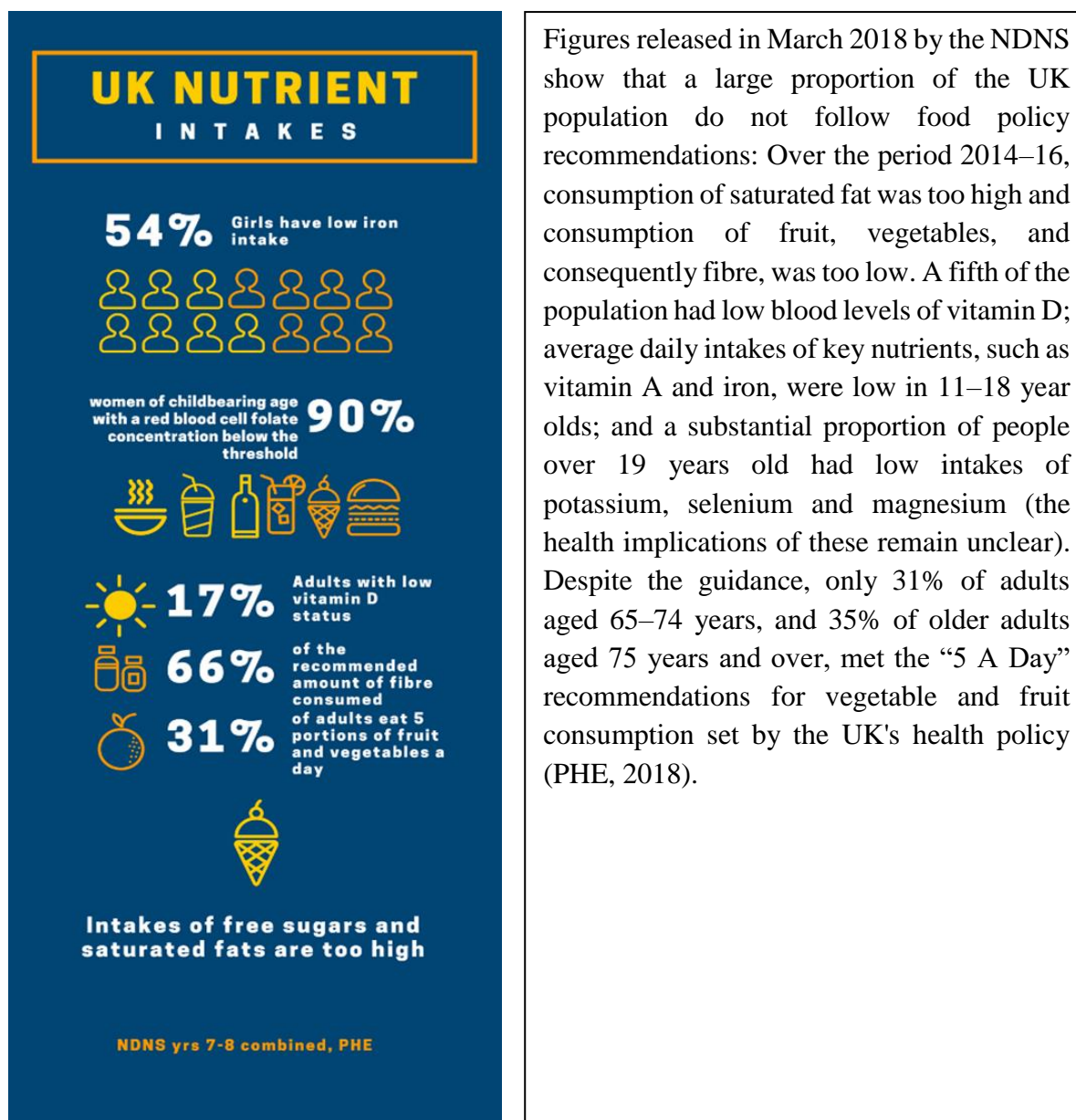


Figure 6. 2014/2015 to 2015/2016 nutrient intakes: National diet and nutrition survey years 7 to 8.

As individuals we struggle to make the healthiest choices, therefore other initiatives have also been developed. The Food Foundation is an independent Think Tank who have introduced a range of initiatives to improve vegetable consumption in the UK. These include ‘Veg Power’, a crowdfunding campaign with Nourish Scotland and the WWF to increase awareness and consumption of vegetables through focused advertising; and ‘Peas Please’, an initiative to encourage food manufacturers and caterers to put an additional portion of vegetables into prepared meals. This combination of ‘nudge’ philosophy and initiatives is aimed so that consumers don’t have to change their behaviour to achieve a healthier diet.

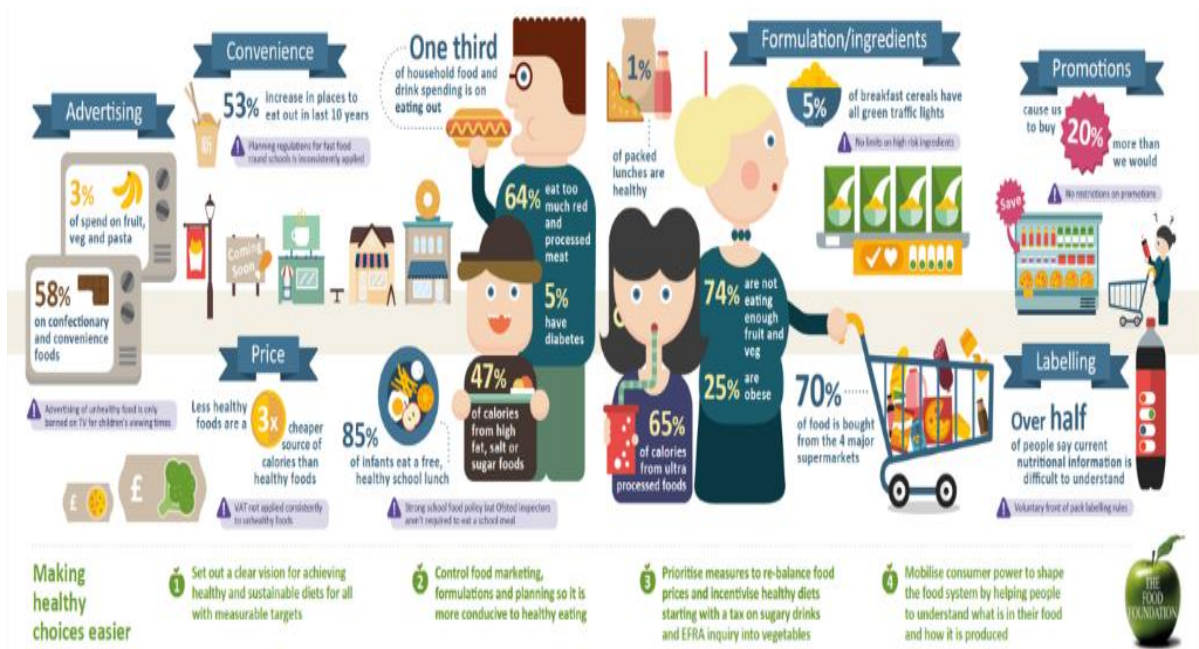


Figure 5. The Food Foundation: 'Making Healthier Choices Easier'

4.3. National dietary guidelines in different countries

During my Nuffield study tour, I had the opportunity to observe and compare national dietary guidelines and practices in a variety of countries. In this section I provide a summary of my observations focussing on Asia (China, South Korea) and New Zealand.

4.3.1. China

China's first nutrition plan was issued in June 2017, referencing dietary recommendations published in 2016. Its aim is to provide guidelines that can be implemented at state and local level, shape food markets and have an impact on food companies. There is also a commitment to reduce food waste.



Figure 6. Food based dietary guidelines, China [Source: FAO]

The dietary advice is prescriptive and sets a daily target of 300–500g consumption of vegetables, including 50% dark vegetables (dark green, red, orange and purple) (FAO, 2018).

4.3.2. South Korea

South Korea uses three different food guides: the commonly used ‘Food Balance Wheel’ (illustrated below); the ‘Roly Poly’ guide targeted at six different age groups; and the ‘Green Water Mill’.

The ‘Food Balance Wheel’ specifies eating at least two different types of vegetables in each meal (FAO, 2018).



1. Eat a variety of foods including rice & other grains, vegetables, fruits, milk & dairy products, meat, fish, eggs, and legumes.
2. Do not skip breakfast.
3. Avoid binge eating or over-eating and increase physical activity.
4. Choose foods lower in salt, sugar, and fat.
5. Drink plain water and refrain from sugary drinks.
6. Avoid alcoholic beverages.
7. Prepare food safely in adequate amounts.
8. Enjoy meals prepared with local produce.
9. Have frequent family meals.



Figure 7. Food based dietary guidelines, South Korea [Source: FAO]

4.3.3. New Zealand

The New Zealand Food and Nutrition guidelines focus on six key areas, summarised in below.

1. Maintenance of a healthy body weight through healthy eating and physical activity;
2. Eating well
 - o Plenty of fruit and vegetables;
 - o Bread and cereals should favour wholegrain;
 - o Include milk and milk products, particularly low-fat varieties;
 - o Include lean meat, poultry, seafood and eggs.
3. Preparing foods or choosing prepared foods which comprise of the following:
 - o minimal fat, particularly saturated fat;
 - o low amounts of salt; use iodized salt where salt is required;
 - o low amounts of sugar; avoid high sugar foods.
4. Keep hydrated, especially with water;
5. If consuming alcohol, do so in moderation;
6. Focus on food safety when purchasing, preparing and storing food. (FAO)



Figure 8. Food dietary guidelines, New Zealand [Source: FAO]



4.4. Practices and initiatives in different countries

4.4.1. China

In both China and South Korea, it was evident that traditional food is frequently eaten outside the home. As the Chinese are becoming more affluent, particularly in cities like Shanghai, they are eating out more which is fuelling the growth of local fast-food businesses. However, a visit to Bakkavor, China, showed that the growth of Western fast-food outlets has not been as popular.

A tour of the wet market in Shanghai established that vegetables are cheap and plentiful. Most produce is brought to the market from the local region and tends to be seasonal; vegetables brought in from further afield are still sourced in China.



Figure 9. Shanghai Wet Market [*author's own photograph*]

Despite their easy availability, figures from the Prospective Urban Rural Epidemiology (PURE) study show that the mean daily intake of vegetables in China is only 1.9 portions. This compares to a daily mean of 3.58 portions in higher income countries (Miller, 2016).

Some of the possible reasons include:

- a) China is categorized as a lower middle-income country (PURE). Rapid income growth, urbanisation and changes in lifestyles (e.g. more women entering the workforce) induced by globalisation have led to a trend towards increased consumption of processed and convenience foods and drinks, and a stronger preference for meat, fish and dairy products (FAO).
- b) There has been a significant reduction in levels of self-sufficiency particularly in growing vegetables following China's rural economic reform. Rural household self-sufficiency fell from 78.2% in 1980 to 51.3% in 1993, while purchased produce increased to 63.7% (Han, 1998).



4.4.2. South Korea

South Koreans have different dietary challenges from most other areas of the world. Traditional foods in South Korea include a high proportion of vegetables, for example: bibimbap, a rice-based dish with vegetables, meat or fish; Korean barbecued meat and vegetables; and savoury rice porridges with meat and vegetables. I saw vacuum packed bracken for sale in supermarkets along with a whole range of leafy green vegetables. There is also a tradition of eating kimchi, a fermented vegetable product usually made from Chinese cabbage and the hot pepper paste gochujang. A conversation with leading dietician Dr Cho-il Kim, revealed that population intakes of vitamins and minerals in South Korea are acceptable but there is concern that consumption of salt is too high due to the large amounts used in the making of kimchi. Dr Cho-il Kim referred to the Korea National Health and Nutrition Examination Survey (KNHANES) statistics 2008–15, which showed that the only minerals that failed to meet the recommended intake guidelines were calcium and potassium, and these were only slightly below optimum (Kim, 2017). However, the reduction of salt in foods continues to be a serious issue requiring attention.



Figure 10. Food shopping in Seoul [*author's own photograph*]

The KNHANES survey also showed an increasing trend in the number of people eating out of the home at least once a day, coinciding with an increase in obesity figures over the same period from 35.3% to 39.7% for men and 25.2% to 26.0% for women (KNHANES, 2015).

The Korean Health Plan, 2020, sets the representative indicator for nutrition as the “Proportion of population with healthy dietary practice”. The plan has five components, one of which recommends consuming 500g or more of vegetables and fruits.

Aside from these dietary recommendations, no other programmes to facilitate increased vegetable consumption or nutritional quality, such as the biofortification of vegetables, have been considered in South Korea due to the high levels of consumption in both variety and volume of vegetables.



Traditional South Korean dishes



- Sanchon vegan temple food (top)
- Kimchi (middle)
- Bibimbap (bottom)

Figure 11. South Korean food [*author's own photograph*]

4.4.3. New Zealand

The 2016/17 New Zealand Health Survey found that 32% of the adult population were obese and a further 34% overweight. The 5+ A Day Charitable Trust was introduced in New Zealand in 2007 to encourage increased fruit and vegetable consumption in the population. Although the campaign message has been successful in reaching 87% of the population, the percentage of adults consuming over 5 portions of fruit and vegetables a day remains low at around 40% (Jerry Prendergast, 2017).



Figure 12. Fresh produce, City supermarket Wellington [*author's own photograph*]



Therefore, New Zealand has adopted a range of initiatives and provided a regulatory support system to facilitate collaboration across research, crop production, manufacture and marketing that enables the fresh produce industry to promote the nutritional quality of the crops, despite limited finances. The food labelling regulations for Nutrition, Health and Related Claims, issued by Food Standards Australia New Zealand (FSANZ) in 2013, adapted part of the European Food Safety Authority (EFSA) regulations as a framework. In the EU, if a business wishes to use a health claim then it has to submit a dossier of evidence to the member country office for approval to support the use of the claim before the product can be marketed with the claim. It is a lengthy process, with no guarantee that approval will be given. In contrast, FSANZ require any food carrying a health claim to pass nutrition profiling scoring criteria. To facilitate this, they have drawn up a list of pre-approved claims which allow self-substantiated general health claims to be made, as illustrated in Figure 19, Chapter 6. This approach makes earlier marketing possible than if all claims required approval before being made. This simpler approach is particularly suitable for fruit and vegetables (Australian Government, 2017). New Zealand's Ministry for Primary Industries is responsible for enforcing this regulation in New Zealand and evaluating the evidence behind self-substantiated claims post notification (Donnell Alexander, 2017). The availability of the pre-approved health claims has enabled fresh prepared products such as **vitalvegetables®** to be created, a range which has levels of nutrients that can support key areas of health.

vitalimmunity® slow

Includes a delicious creamy dressing.

25% OF YOUR RECOMMENDED DAILY INTAKE OF THE ANTIOXIDANT VITAMIN C PER SERVE

VITAL IMMUNITY

A good source of the antioxidant vitamin C and vitamin A to help maintain a healthy immune system. **vitalimmunity® slow** has been regularly tested to ensure each 100g serve of salad contains a minimum of 25% of your recommended daily intake of the antioxidant vitamin C.

Ingredients: green & red cabbage, kale, carrot, celery, red onion, coriander

| AVERAGE QUANTITY | PER SERVING | PER 100g | PER SERVING (WITH DRESSING) | PER 100g (WITH DRESSING) |
|------------------|---------------|---------------|-----------------------------|--------------------------|
| Energy | 115kJ (27Cal) | 101kJ (24Cal) | 543kJ (130Cal) | 543kJ (130Cal) |
| Protein | 1.3g | 1.7g | | |
| Fat, Total | 0.3g | 0.4g | | |

Figure 13. Pre-approved health claim for a healthy immune system [www.vitalvegetables.co.nz]



Another initiative includes the ‘Reduced chip fat programme’ trialled in Matamata, NZ by a consortium led by The Chip Group (part of Potatoes New Zealand Inc.) to reduce the fat and salt content in hot chips through the training of chip shop operators, as illustrated in Figure 16. This led to a reduction in the average fat per gram in hot chips from 9.6% to 7.8% compared to the national average of 10.8% (Underwood, 2017). This is an example of ‘choice editing’ on the part of the food industry; i.e. consumers who already buy the product will benefit without changing their behaviour, and new consumers may be attracted to buying the product through its health messaging.

WHAT'S INVOLVED?

FREE online training
Our FREE training is available online or delivered in person at a training workshop.

It covers everything you need to know about cooking and preparing deep fried potato chips.

The training involves:

- a series of short video clips;
- quiz questions;
- official training certificate upon completion;
- a shortened refresher course.

PROOF IT WORKS!

Matamata town makeover
Before training the average fat content was 9.6%. After training this reduced to 7.5%.

As a result of completing The Chip Group training, ten operators serving hot chips removed 1711kg of fat from the Matamata food supply per year (equivalent to three trailer loads full of unnecessary fat).

Proving that making small changes to the way you cook can have a huge impact on the fat content of your chips.

"Get trained to play your part in improving the health of your community."

The Chip Group is a division of Potatoes New Zealand Inc.

Supported by Trade Members:

Mr. Chips, Talley's, McCain, Potatoes NEW ZEALAND

Contact: Kate Underwood
Training & Education Manager
kate@potatoesnz.co.nz
022 066 8711

Taking 1711kg of fat from the Matamata food supply

www.thechipgroup.co.nz
www.facebook.com/thechipgroup

Figure 14. The ‘Reduced Chip Fat’ programme, NZ
[image supplied by Kate Underwood, The Chip Group]

Not all vegetables have the same combinations or levels of nutrients, even within the same variety, making it difficult for consumers to know which vegetables will be the best for good health. This is a worldwide issue but to address this several producers in both New Zealand and Australia have taken advantage of the Ministry of Primary Industry’s (MPI) health and nutrition claims to provide a category of prepared vegetable products with optimum levels of vitamins for promoting health. This allows consumers to make informed choices to purchase premium products for wellbeing. Examples include **vital**vegetables®.

Other strategies include vegetable enhancement, e.g. vitamin D enhanced mushrooms, and biofortification which allows the agri-food industries to improve the nutritional value of vegetables at the growing and harvesting stage.

Overall, whilst vegetable consumption may not be increasing in New Zealand, small steps are being made in the direction of improving nutrition from vegetables in both greater consumption and qualities of the products.



4.5. Conclusion

The three focus countries I visited on my tour have diverse and different cultural, political and economic backgrounds. Traditional marketing in both China and South Korea ensures sufficient availability of fresh vegetables, but rapid economic growth and urbanisation has led to changes in dietary trends with lower vegetable consumption and greater consumption of convenience food.

Higher income countries where the population is consuming food high in calories but low in nutrients, also face challenges. Over 80% of New Zealanders have a good understanding of the 5+ a day concept but this is not reflected in their levels of fruit and vegetable consumption. However, various initiatives by producers to improve the nutritive value of vegetables are allowing consumers to make informed healthier choices when purchasing vegetables, as opposed to simply increasing levels of consumption. Choice editing, e.g. the removal of fat from chips by the food service sector, may remove consumer choice as the consumer may be unaware of the change in their product, but results in consumers eating more healthily without having to change their behaviour. Biofortification of crops or food products to produce vegetables with higher nutritive value is another strategy being practiced in higher income countries.

These multi-disciplinary approaches are discussed in greater detail in the following chapters.

There is an increasing trend in some higher income countries, including the UK, towards plant-based eating, such as vegetarianism and veganism. Although market forces will determine which crops become the most popular, this trend offers an opportunity to engage with consumers and put forward vegetable products which meet nutritional, cultural and affordability needs.

Neither China nor South Korea have adopted biofortification or specific initiatives to increase the consumption or nutritive value of vegetables and fruit in their populations and focus more on government dietary recommendations. China is the most prescriptive with both the highest quantity of vegetable consumption by weight and the type of vegetables to eat. However, my observations during my study tour suggest that producer and supplier led initiatives toward informed consumer choice or choice editing, such as the Chip Group in New Zealand and **vital**vegetables®, may be more effective for increasing vegetable and fruit consumption than government policy recommendations in those countries.



5. Agriculture and changes in the nutritional quality of vegetables

The nutritional quality of food can be influenced, both positively or negatively, by farming practices and changes in the agri-food industries. In this chapter, I discuss how biofortification can be applied to improve nutritional quality of vegetables. In Chapter 7, I look at how ‘nutrition-smart agriculture’ can be used to increase nutritional quality to improve human nutritional status.

5.1. Has the nutritional quality of crops changed over time?

During my study tour I had the opportunity to hear the botanist James Wong and others talking about the changes in nutritional quality of our food over time. There is a lot of debate as to whether reported changes have been correctly calculated and if the changes are significant.

McCance and Widdowson compared food composition data between the 1940s and 1990s, and found evidence that the level of micronutrients in vegetables appeared to have reduced (McCance and Widdowson; 7th Ed PHE). A further study by Davis (2009) indicated that minerals such as calcium, magnesium and potassium have been negatively affected over time (Davis, 2009). One hypothesis is the ‘dilution effect’ where yield-focused breeding has increased the carbohydrate content of crops at the expense of micronutrients (Thomas, 2007).

However, the methodology used in these comparisons has its critics: because the samples were taken at random, they differed between country of origin, variety and time of year (Marles, 2016). Studies that take crops grown side by side from different eras may provide a better guide to changes in nutrient levels over time.

Despite these possible changes, the reported loss of nutrients represents a small change that is not clinically significant and is within the natural levels of variation in a crop from season to season. Therefore, further work is needed in this area to monitor the levels and establish the consequence to human health.

5.2. Biofortification

Biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology (WHO, 2016). It has been used successfully in countries where malnutrition is a problem, for example, to enhance beta-carotene levels in sweet potato to improve levels of vitamin A and reduce blindness-related issues in the population.

The issue of whether biofortification is necessary in the UK can be illustrated by the fact that intakes of certain micronutrients, such as potassium, selenium and magnesium are below optimum. One solution is to persuade the population to eat more vegetables, another is to



enhance the nutritive value of those vegetables so that the consumer gains the benefits without having to increase their levels of consumption.

In an ideal world where consumption of vegetables is a minimum of 3 portions (240g) per day, then, like in South Korea, there would be no requirement for biofortification.

There are three main methods of biofortification: breeding, agronomic practices, and management of the environment (Figure 17).

Examples of biofortification methods

| | |
|---------------------------------|---|
| Breeding | • Beneforte Broccoli |
| Agronomic practices | • Plant stress • Addition of nutrients e.g selenium |
| Manipulation of the environment | • Use of UV light to increase vitamin D production in mushrooms |

Figure 15. Examples of biofortification methods for specific crops

5.2.1. Breeding

Plant breeders now have the technical capability to focus on specific nutrients in plant crops and breed for those traits so that they are expressed at a certain level. These developments have been driven by demand from retailers and consumers wanting to improve health and promote nutrition as selling points in addition to flavour and sweetness (Tournebize, 2018).

I met with the Rijk Zwaan plant breeding company at Asiafruit, Hong Kong in winter 2017. They are developing a new range of vegetables (branded ‘Sensational Ingredients’) with enhanced nutritional content: e.g. the Sweet Palermo pepper which is richer in vitamin C and a good source of folate; or vegetables with higher pigment levels containing betanins and carotenoids such as those found in beetroot and carrots.



Figure 16. Rijk Zwaan Sweet Palermo pepper from the ‘Sensational Ingredients’ range 1.7x more folate and 2.5x vitamin C than Kiwifruit



In order to be accepted into the Rijk Zwaan ‘Sensational Ingredients’ range, vegetables must meet the EFSA increased nutrition claim of 30% higher than an average crop. For each grower Rijk Zwaan take a minimum of five measurements to establish the levels. They then provide advice to the grower on how to manage the crop to maintain the required levels and how to carry out the necessary nutritional testing to validate any claims used in the final product.

5.2.1. Agronomic practices

Elsoms seeds, vegetable plant breeders based in the UK, focus their breeding programme on agronomic traits, for example, quality, yield, disease resistance and shelf-life. Their view is that the decision to focus on specific nutrients would need to be demand driven and currently the communication about the needs of the consumer is passed up the chain from retailers to the plant breeders.

5.3. Conclusions

It has been found that the focus on breeding for yield increases the carbohydrate content at the expense of micronutrients, however, the micronutrient loss is not significant for human nutrition. Biofortification is useful tool that can be applied but there has to be a tangible benefit for the consumer and a desire for biofortified products in the market.

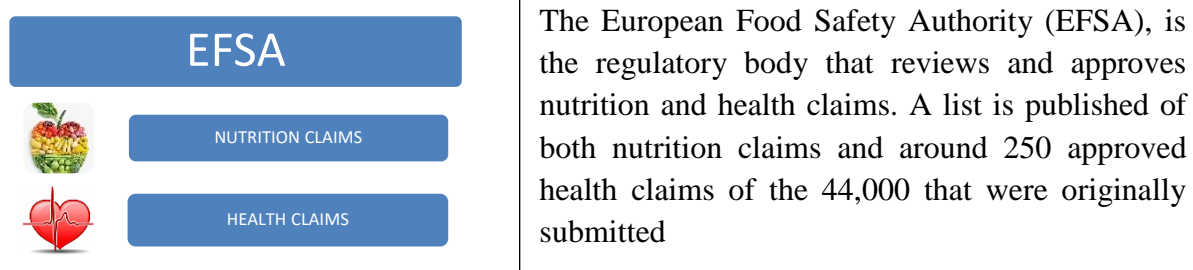
The financial case for plant breeders to develop higher nutrition products is not enough without the support and commitment from the rest of the supply chain (Tudor, 2018).



6. “The Fabulous Five”

The NDNS have identified several nutrients that are not being consumed in high enough quantities by the general population in the UK. In this chapter I focus on five different vegetable products to demonstrate how a combination of producer and supplier-led initiatives can improve vegetable consumption and promote good health.

6.1. Nutrition and health claims regulation



It is only permissible to use nutrition and health claims on foods and products that are included in the EFSA list. If an organisation wants to use a health claim that is not on the list, they must prepare a dossier of scientific evidence and submit it to the Nutrition Legislation team within the Department for Health and Social Care (DHSC). Successful applications are passed to EFSA with further supporting information to be validated and published or denied approval. The system is lengthy, expensive and has no guarantee of approval. The manufactured-foods sector has had more success in gaining approval for health claims given to food products; in contrast, prunes (dried plums) are one of the few whole foods that have obtained positive scientific approval and granted a health claim from EFSA.

The UK's potential departure from the EU gives it an opportunity to review current health claims and possibly adapt the system for the fresh produce industry to better communicate the health benefits of their produce to the consumer. The ideal solution would be to provide a list of pre-approved claims with consumer-friendly wording, similar to the method used in New Zealand (discussed in Chapter 4 above). The table in Figure 19 gives an example of a pre-approved health claim in New Zealand.



| Food or property of food | Specific health effect | Relevant population | Context claim statement | Conditions |
|---------------------------------------|--|---------------------|--|--|
| A high intake of fruit and vegetables | Reduces risk of coronary heart disease | | Diet containing a high amount of both fruit and vegetables | a) Claims are not permitted on juice blends etc. b) The food must contain no less than 90% fruit or vegetable by weight |

Figure 17. Conditions for permitted high level health claims in New Zealand taken from Schedule 4 Nutrition, health and related claims relating to Standard 1.2.7 Nutrition, health and related claims

Nielsen and Innova Market Insights have recently released their food trend reports for 2018 and although the health trend may have already peaked, the trend in concern about general wellbeing is increasing. Consumers are also looking for more transparency and Innova has listed ‘Mindful Choices’ as its number one trend. This demonstrates that consumers want information about what is in their food and how it is produced to make decisions about health, sustainability and ethical issues. Fresh produce businesses are well placed to take advantage of this trend. Nielsen advises that health facts can be pulled out for the consumer but must be linked to the actual health benefit to help consumers through their health and wellness journey.

6.2. “The Fabulous Five”

The five vegetable products I have selected on to demonstrate how producers and suppliers have combined to promote increased consumption of their products are Beneforte® broccoli; watercress, beetroot, Potatoes and vitamin D enhanced mushrooms. I also explore some of the other potential health claims attributed to these vegetables that could be used to support the initiatives to promote their consumption.

6.2.1. Beneforte® broccoli



Figure 18. Beneforte® broccoli, Monsanto



Beneforte® broccoli was introduced to the market to provide a mainstream product with added health benefits for consumers. Beneforte® broccoli was launched in the UK in 2011: currently it is still a niche product. The goal of reaching 100% market penetration as a mainstream product within 10 years is still to be achieved.

Research suggests that people who consume several portions of cruciferous vegetables may have higher levels of protection against CVD and certain types of cancer (Traka *et al.*). Glucoraphanin is present naturally in broccoli. It is converted to sulphoraphane, a compound that switches on the antioxidant genes in the cells of body. These genes are important for protecting us from environmental toxins. The Beneforte product has 2–3 times the level of glucoraphanin present in normal broccoli. This has been achieved by introducing a trait from a wild broccoli found in Southern Italy by cross-pollinating it with a commercial variety. The levels of glucoraphanin in ordinary broccoli vary so the Beneforte product has been developed to provide a consistent source of this compound.

Despite the success in developing Beneforte® broccoli, marketing it to the consumer with a valid EU health claim remains a challenge. Currently there are no authorized EU health claims that can be made for the presence of glucoraphanin in a product. It is hoped a final clinical trial will generate sufficient evidence to gain approval. Monsanto, now Bayer, will probably wait until a formal health claim is approved in the EU before expanding to other countries. In addition, the trait will need to be bred into enough varieties to make it commercially viable.

This is not the only challenge to marketing Beneforte® broccoli as a healthy product: the enhanced broccoli has to be recognisable for consumer confidence and to gain consumer trust. Currently, there is no distinguishable visible difference between high-glucoraphanin broccoli and standard broccoli. One strategy has been to approach the food service sector to incorporate the product into prepared meals.

The establishment of a strong Beneforte brand may be the next main step in the growth of product sales. By educating the consumer to the benefits of eating broccoli in general and making it more convenient and available under the Beneforte brand, the position will naturally become stronger. Engaging with consumers is vital until an approved health claim becomes available which will enhance to the overall message.

Added health claim opportunities

Diabetes: Chromium, also present in broccoli, contributes to the maintenance of normal blood glucose levels ((EC) No 1924/2006, 2006).

6.2.2. Watercress

In common with most dark green leafy vegetables, watercress is a good source of iron, calcium and a range of essential vitamins, and is also another cruciferous plant with similar health benefits to broccoli.



Figure 19. Watercress

[Copyright: kariphoto / 123RF Stock Photo]

The Watercress Alliance sponsored research in 2007 to investigate the health benefits of watercress. Initial results revealed the presence of phenethyl isothiocyanate (PEITC), an isothiocyanate compound that has been linked to a decrease in DNA damage in white blood cells and an increase of levels of the antioxidants lutein and B-carotene in the blood. These compounds may help reduce the risk of cancers by protecting cells from the effects of harmful free radicals (Gill, 2007).

Another trial is investigating the ability of watercress to repair DNA damage caused through exercise. Results suggest that watercress can dampen the body's response to stress. Further research is being carried out to identify possible applications for watercress to aid exercise performance.

As with Beneforte® broccoli, there are currently no EFSA approved claims for the crop watercress or isothiocyanates. This prevents the watercress industry from communicating these benefits to consumers until further large clinical trials are carried out to generate sufficient data for the EFSA dossier.

In the short to medium term, building on the current watercress PR campaign and finding ways to get convenient meal solutions that include watercress would help raise its profile. The foodservice and meal kit sectors are continuously expanding their ranges of plant-based meals and healthy meals and watercress sits very neatly in that area.

Added health claim opportunities

Watercress is a good source of calcium, vitamin C and vitamin K, for bone health; and folate, iron and vitamin C, to improve immunity.

6.2.3. Beetroot

Beetroot is a good source of folate (one of the B vitamins) and important minerals including iron, betaine and potassium. Beetroot also appears effective at regulating blood pressure (Siervo, 2013) and beetroot juice has become popular as a sports recovery drink.



The introduction of juice products to the market has been a useful way to improve the convenience of vegetable consumption.

Along with the increasing interest in plant-based food products and diets, beetroot has gained popularity with the trend towards purple vegetables.



Figure 20. Love Beets beetroot range

Added health claim opportunities

Because beetroot contains iron and folate, it can promote immunity. It also contains Betaine which contributes to normal homocysteine metabolism (Entry ID 4325) ((EC) No 1924/2006, 2006). However, in order to make this claim there must be 500mg of betaine per quantified portion, which would mean eating a whole pack! There is the added complication of explaining the benefit to metabolism to the consumer in clear, understandable language.

6.2.4. Potatoes

Potatoes were once the main source of vitamin C in the UK diet, not because of their high vitamin C content but because of their ubiquitous presence in the population's diet. In general, vegetables (excluding potatoes) only contribute around 4% of our calorie intake in the UK; potatoes and savoury products contribute 9%; whereas cereals contribute about 32% (British Nutrition Foundation, 2009).

Potatoes, when eaten with the skin on, are high in potassium. For the majority of the population, potassium promotes good health by contributing to the normal functioning of the nervous system and heart health. However, for a sub-population of people with chronic kidney disease, foods high in potassium are detrimental to health. This is discussed as a case study in Chapter 8.



Marketing communication around potatoes mostly focuses on the fresh product cooked by the consumer. However, the proportion of cooked and processed potato products is growing. The total value of the worldwide potato trade was €12 billion in 2016 and precooked frozen chips (fries) represented €6 billion of this total (Faulkner, 2017). A change in focus toward prepared potato products could communicate the health benefits to consumers more directly.

Potatoes provide resistant starch which helps to increase production of short chain fatty acids in the gut and modify the gut bacteria*. The trend for gut health beneficial meals is growing and prepared potatoes should play a huge part in fulfilling that need. For example, promoting the fibre content of cooked potato wedges or jacket potatoes in a ‘gut healthy’ meal. If this message is successfully communicated, potatoes could become the new ‘avocadoes’ of wellness trend.

*[*See Appendix 1 for more information about gut health.]*

Added health claim opportunities

If the level of potassium can be established in a cooked potato product as sufficient for a claim, then the following health claims could be used (Entry ID 320):

- Potassium contributes to normal muscle function (Entry ID321);
- Potassium contributes to the maintenance of normal blood pressure ((EC) No 1924/2006, 2006).

6.2.5. Vitamin D Enhanced Mushrooms

The technique for enhancing vitamin D in mushrooms is now well established, and New Zealander growers were among the first in the world to commercially produce vitamin D enhanced mushrooms. Te Mata was the first company out of the six major mushroom growers in New Zealand to launch the product.

Labelling of biofortified products focuses on their health claims to differentiate them from the standard products; consequently, supermarkets can sell them at a higher price. However, the price paid back to the growers from the retailers does not necessarily justify the extra cost of innovation and successful implementation of a new technology (Michael Whittaker, 2017). I visited Te Mata mushrooms in Hawkes Bay and spoke with Michael Whittaker, the owner, about how the product has been received. Michael’s view was that regulation does not stop growers from doing biofortification but that the regulatory process is a barrier for innovation in the health space.



Figure 21. Te Mata Mushrooms and Meadow Mushrooms, New Zealand [*company photos*]

Meadow Mushrooms are the largest producer of mushrooms in New Zealand, however they do not produce vitamin D enhanced mushrooms. Market research suggested that consumers thought there was too much nutritional information on the packaging and they just wanted to know what to do with the mushrooms. The resulting rebrand now focuses on the end use e.g. Portobello Mushrooms for burgers, Swiss Brown for stir-fry or White Sliced for pizza. The nutritional information has been reduced to 'info bites', nuggets of information about the vitamins and minerals that are unobtrusive but helpful (Melanie Rushton, 2017).

Currently vitamin D enhanced mushrooms are mostly sold in retail outlets. Incorporating them into the food service sector remains a challenge, but because the levels of vitamin D remain stable in mushrooms even after cooking, there are opportunities for their use in the manufacturing and food service sector: Banken Mushrooms in The Netherlands recently received approval from EFSA to market vitamin D enhanced mushrooms; and Monaghan Mushrooms was the first company to launch the same product in Ireland. Banken looked wider than the fresh retail market and have introduced a range of mushroom burgers that offer a vegetarian meal solution with enhanced nutrition (Edward Vonk, 2018).

Added health claim opportunities

Although this isn't specific to vitamin D enhanced mushrooms, firms such as Apetito have developed meals with added vitamins and minerals including vitamin D and calcium to support their target demographic: older adults who need assistance in their daily lives (Apetito, 2018). The use of biofortified vegetables or a range of vegetables high in key nutrients is an opportunity that is being explored.



6.3. Conclusion

There are certain claims, for example enhancing immunity, bone health or metabolism, that are particularly applicable to vegetables. However, these claims are not used as marketing tools because of the difficulty in communicating this information to the consumer. A combination of branding with an easy to understand message would help promote consumption of vegetable products. The multi-disciplinary approach discussed in the next chapter illustrates how this can be achieved.

If the UK leaves the EU it will have an opportunity to review the system of how labelling regulations and claims on produce can be amended to facilitate increased vegetable and fruit consumption, for example, a system similar to that used in New Zealand.



Chapter 7. The multi-disciplinary approach from concept to consumer – Case studies

The concept of ‘nutrition-smart agriculture’ is based on providing outcomes for improving human nutritional status whilst achieving farm objectives of increased productivity and profit. It currently has high focus in sub-Saharan African and South Asian countries. Non-governmental agencies such as Harvest Plus are using biofortification techniques to breed vitamins and minerals into everyday crops to alleviate hidden hunger or micronutrient deficiencies.

In the UK, I have found that the networks for bringing together different parts of the food system to collaborate on nutrition-smart agriculture projects are not so well developed. Until recently the funding streams for research have focused on single disciplines. They don't facilitate multi-disciplinary working.

I attended events run at Rothamsted, N8 Agrifood, and Nuffield Council on Bioethics where questions were asked on whether scientific research can be improved by including disciplines not normally associated with this field, such as psychologists and geographers. In order for these disciplines to make an effective contribution, they would have to be involved throughout the project and not as one social scientist put it “at the end to check whether consumers will use it”.

There are many different relationships in a food system. There is the classic supply chain relationship between grower, manufacturer and retailer, then there are specialist relationships, for example between scientists carrying out research for manufacturers and retailers.

Engaging with many parts of the food system is a useful way to develop product that meet a range of consumer needs.

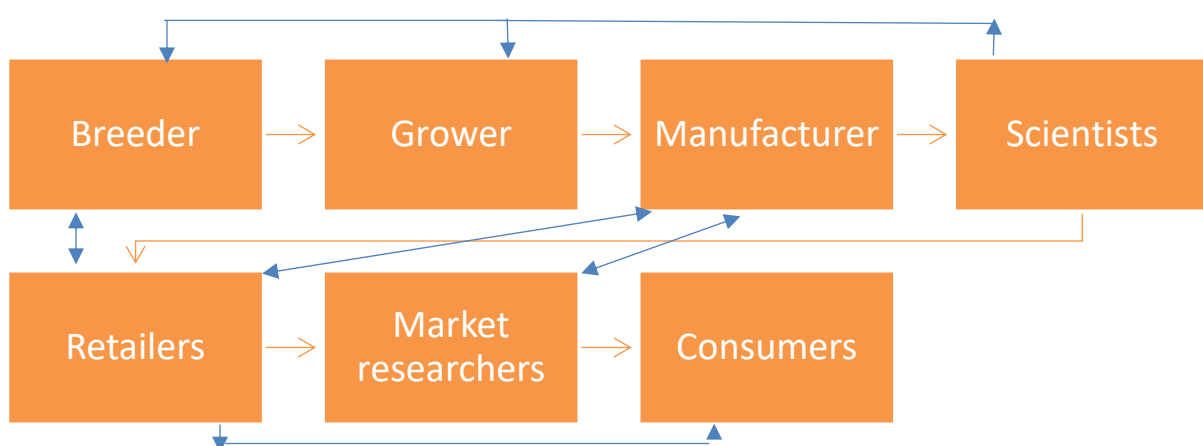


Figure 22. Connecting the food supply chain



Behavioural change in consumers takes time. An integrated approach of nudging consumers towards the right decisions, for example through choice editing, or incentivising healthy choices could help accelerate progress. Consumers increasingly buy meal solutions, and with the current trend towards plant-based food products these could include the vegetable category. Lessons from the private sector, including the use of branding, storytelling and engaging with consumers to show that a product delivers a healthy and convenient meal solution, have been successfully used in different markets. Some of these are discussed in the following case studies.

7.1. Case study 1: **vitalvegetables®**



Figure 23. **vitalvegetables®** [Snapfreshfoods.com]

vitalvegetables® is a branded range of prepared mixed vegetable products first introduced in New Zealand and Australia in 2012 following 10 years of research. The range was designed to take advantage of the health and nutrition claims to promote consumer health issued by the MPI for New Zealand and Australia, as discussed in Chapter 4. At the time of writing this report in July 2018, the New Zealand range included six products in four categories: **vitalimmunity®**, **vitalheart®**, **vitalsight®** and **vitalbones®**. The products are assessed every six months to verify their health claims and ensure they have optimum levels of vitamins, principally, vitamin C, vitamin A and vitamin K.

The brand was the result of a multi-disciplinary, collaborative project between Australian and New Zealand government and research departments together with breeders, growers and the manufacturing, retail and marketing sector. The research programme was funded by Horticulture New Zealand, Plant & Food Research and the Department of Environment and Primary Industries Victoria, with Horticulture Australia Limited matched funds from the Australian Government and support from the New Zealand vegetable sector (source: www.vitalvegetables.co.nz).

The main stakeholders for the **vitalvegetables®** range included:



- Research partners: Plant & Food Research and the Department of Environment and Primary Industries, Victoria Germplasm
- Breeders/growers
- Nutritionists (in particular for product promotion – a well-known face was used to give credibility)
- Chemists for analytical
- Consumer end researchers (e.g. an output was a publication on Horticultural products as functional foods – a consumer perspective).

More specific consumer work around the final product claims was also carried out (Lister C. , 2018).

Their principle roles and steps in the project were as follows:

Germplasm partners were the key players in plant breeding and seed supply. They were brought in at the initial stages of the project when the original concept was to have single crops as the product.

There was extensive interaction with various vegetable growers during the field trials process. These were conducted on commercial operations and compared to standard varieties of the vegetables.

The project was funded by a variety of horticultural, research, and science and technology organisations in both Australia and New Zealand, demonstrating that the wider vegetable industry jointly contributed toward the research and development stage.

Similarly, several marketing companies, including Snap Fresh Foods (now Golden State Foods) and MG Marketing, collaborated to launch the final products for retail (Lister C. , 2018).

This multi-disciplinary approach to developing a product is unique and has been the key to ensuring this range of enhanced nutrition vegetable products became a commercial reality. In the UK, it is rare to have projects where all sectors of the food chain are consulted and involved at the same time. Typically, one sector, e.g. breeders, only communicate with one or two other sectors, e.g. growers and food processors.

The **vital**vegetables® project demonstrates that the whole food system is relevant when designing a product as a tool for promoting consumer health, to ensure that the product delivers a healthy meal solution that is affordable, convenient and tasty.

this collaborative, multi-disciplinary concept from research to the consumer is clearly illustrated in Figure 26:



Figure 24. vitalvegetables development process

7.2. Case study 2 : Zespri



Figure 25. Zespri Kiwifruit at Asiafruit 2017 [author's own photograph]

Zespri was established in New Zealand in 1997. It is an international business that grows and markets Kiwi fruit. Investment was not just focused toward the consumer-facing side of the brand; it took time and significant investment to develop a product that could be grown



consistently in different geographical regions and deliver the quality and taste attributes that the brand stands for in each market. Some of the tools used included defining product specifications to meet high safety and quality standards and training growers in techniques from orchard selection to pest and disease management.

Figure 28 illustrates the length of time Zespri invested in preparing the scientific evidence to submit for a health claim.

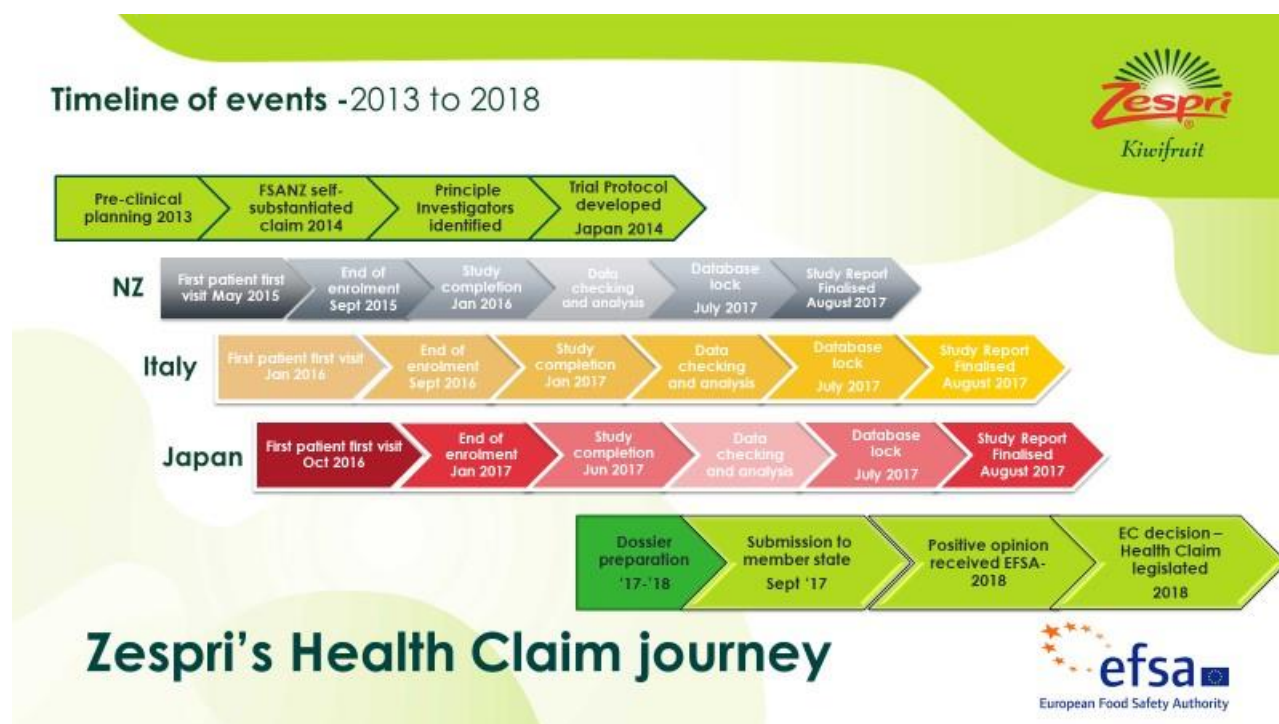


Figure 26. Zespri's health claim journey [Dr Juliet Ansell, Innovation and Health Lead, Zespri]

This is only one part of the story, there were also significant marketing challenges. As discussed in Chapter 6 (“The Fabulous Five”), lack of differentiation is a common problem in the fresh produce sector, regardless of variety and provenance. Zespri has successfully created a strong brand behind its Kiwi fruit range. The principle message that Zespri promotes across its different markets is the ‘making life taste better’ strapline. The health and nutrition messages are communicated as a secondary message behind taste and convenience. The establishment of the brand has taken place in layers starting with introduction and familiarisation, followed by educating the consumer about what the product is, then demonstrating how the product can fit into the daily life of a target consumer, for example a busy working mother. Although the health claim was available to use in the New Zealand market, it is still under EFSA review in Europe in 2018, so the marketing focus has been different, (Jiunn Shih, Global General Manager of Marketing, 2017).

The development of a good quality product, that is safe and affordable, and that consumers recognise as adding value to their lives has been as a result of the company’s multi-disciplinary approach.



7.3. Case study 3: Love Beets



The Love Beets brand was created by G's in the USA to provide theatre and excitement in the beetroot category. Over time the brand has been established in the UK, Australia, a range of countries in Asia, The Netherlands and South Africa.

A conversation with Graham Forber, Managing Director of G's Fresh Beetroot, revealed that prior to Love Beets, there was little branding or innovation in the beetroot category. New products were introduced by adding flavours to cooked or pickled beetroot or by using new processing or packaging technology. Instead, G's used a multi-disciplinary approach to bring the beetroot and the brand to the attention of the consumer; for example, research carried out by Newcastle University identified the health benefits of beetroot so these could be communicated to the public, as illustrated below.

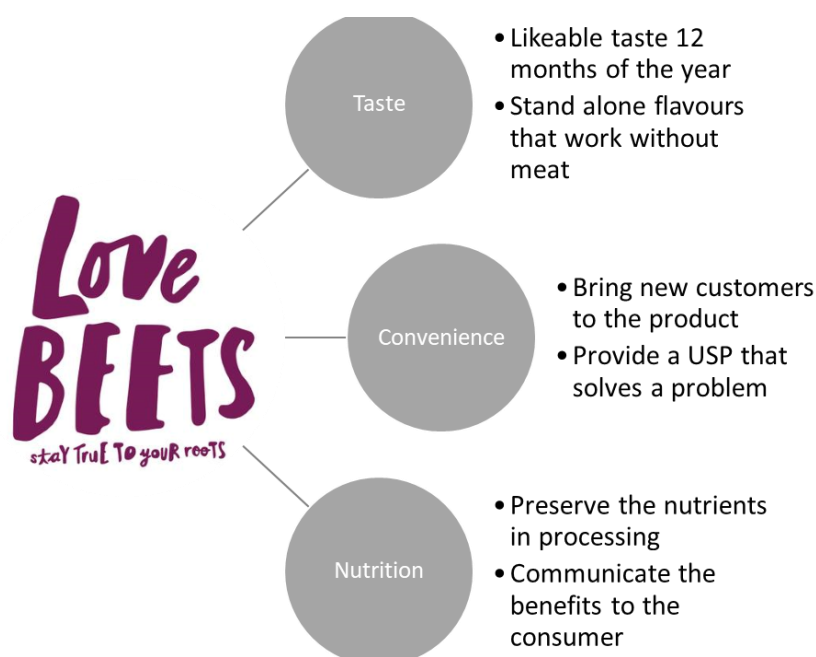


Figure 27. Love Beets Multi-disciplinary approach to product development [author's own illustration]

By communicating the needs of the consumer across the food supply chain, different nutritional needs within the population have been discovered. G's has been able to identify new areas and



products to promote for example a beetroot drink for sports enthusiasts; products that could help improve arthritis and mental agility in older adults with physical impairment; working adults needing convenience food. This has been instrumental in initiating growth in this category and the development of the Love Beets brand.

The recognition of different consumer needs is helpful in product development. This does not necessarily mean that several different products need to be marketed but does show how to communicate the benefits of the product across the different groups.

7.4. Conclusion

The three organisations in these case studies have all used multi-disciplinary working from breeder through to consumer research to establish the needs of consumers and how their products can meet those needs. Branding has been used effectively to communicate with the consumer and health messaging has been included as part of that message rather than being the only message.

This targeted approach demonstrates the importance of bringing all the elements of the food system together to achieve a successful outcome.

In the next chapter I take a problem identified by dietitians and look at how it can be resolved by growers, food manufacturers and retailers.



8. Potassium in vegetables - A case study

An aspect of nutrition which is of interest to me is the high level of potassium in potatoes and its effect on people with Chronic Kidney Disease (CKD). As part of my Nuffield study tour, I hoped to identify strategies that could help this population group in the UK.

8.1. Background: Potassium and people with CKD

Currently 5.2% of the population in the UK have chronic kidney disease (CKD) stages 3–5. This is six times higher than the number of patients with coeliac disease in the UK. People with advanced-stage CKD (eGFR less than 30) are prone to hyperkalaemia (high potassium level in their blood) because their kidneys lose the ability to excrete potassium effectively. Hyperkalaemia can be fatal as it causes cardiac arrhythmia.

High potassium levels in these patients can be prevented only by following strict dietary advice with close monitoring. Furthermore, some of the medication used in CKD has side effects that can cause potassium retention.

Potassium is a mineral that is important to heart health and benefits those in the population without CKD. Whereas the food labelling system for salt (sodium) is defined and used globally, a similar labelling system for potassium levels is lacking in most countries. Furthermore, the desire to reduce salt in food has resulted in replacement of sodium with potassium. This exacerbates the problems for those with CKD.

Once kidney function is reduced to below about 30% of normal, the kidney can no longer adequately control blood mineral levels, particularly sodium, potassium and phosphorus. As the primary source of these minerals is the diet, the patient needs to carefully select foods in an attempt to maintain blood minerals at their normal level. This requires avoiding a substantial number of foods, careful portion sizing and consuming a diet particularly poor in nutrients, especially fibre. The poor kidney function also results in a build-up of other chemicals in the blood, resulting in these patients being particularly tired and lacking energy.

This group of people may also have co-morbidities, such as type 2 diabetes, and may be struggling to manage a range of dietary recommendations to control both conditions. Vegetables can be a particularly important part of the diet for this population group.

8.2. Are growers part of the solution to optimise potassium levels in food?

Fruits and vegetables, and most potatoes varieties are a good source of potassium, however the amount can be reduced through cooking or processing.

Most of today's consumers can walk into a supermarket or convenience store and buy prepared meals or snacks containing potato products with little thought for the consequences to their health. People with CKD have two options: to cook meals from scratch ensuring that vegetables with a high potassium content are boiled and drained; or avoid a whole list of prepared foods



that could potentially be too high in potassium. Furthermore, excess blood levels of potassium and phosphorus are common within this group of patients. The expectation that they should select only limited foods, process them properly to minimise minerals such as potassium and phosphorus, and cook all meals from scratch is impractical. Pre-processed foods are a key part of the lives of these patients and the lack of labelling information for these minerals is particularly debilitating.

Dietitians recommend that people with CKD limit their intake of potassium by selecting foods containing less than 200mg/100g. Figure 30 gives a list of vegetables where this may be achievable after cooking (McCance and Widdowson, 7th Ed PHE). This shows that old potatoes, including varieties such as Maris Piper, Desiree, King Edwards and Harmony have potassium levels higher than 200mg/100g even after boiling.

| | Mg/100g potassium raw | Mg/100g potassium boiled |
|----------------------------|-----------------------|--------------------------|
| Aubergine | 210 | 170 |
| Broccoli | 397 | 212 |
| Green Cabbage | 288 | 187 |
| Carrots, young | 240 | 160 |
| Courgette | 360 | 210 |
| Curly kale | 450 | 160 |
| Leeks | 260 | 150 |
| Mushrooms | 378 | 216 |
| Peas | 330 | 230 |
| Potatoes, old (flesh only) | 443 | 365 |
| Spinach | 500 | 230 |

Figure 28. List of foods with potassium levels higher than 200mg/100g in raw state [*Data from McCance and Widdowson, 7th Ed PHE*]

Enabling people with CKD to access a wide range of vegetable products and maintain a healthy and enjoyable diet is achievable if growers, food manufacturers, retailers and dietitians work together.

8.3. Food processing to reduce potassium levels for people with CKD

One of the objectives of my study tour was to find out whether there are growing methods and processing methods that could reduce the potassium quantities in potatoes and potato products to a level that is safe for people with CKD to eat.

I carried out a case study in conjunction with the University of Reading to investigate potassium levels in potatoes focusing on the following questions:

1. Does cooking potatoes reduce the potassium content significantly?



2. How does the potassium level of processed potato compare with the potassium level of other processed high carbohydrate foods?
3. Does the potassium level of the raw material change with geographical location or potato type?

Methods: Samples of Maris Piper were taken from AH Worth potato crop lifted in September 2017 in three different locations. A second set of samples was taken from the stored crop in February 2017. Analysis of the potassium content was taken with skin on, skin off raw, and skin off and cooked.

Results: The results supported existing data that potassium levels can vary within the same crop and that the greatest proportion of potassium is in the raw skin rather than the raw flesh. However, a reduction in potassium levels was achieved by peeling and boiling the potatoes to make mash.

The results are documented in the academic study “The effect of processing on the potassium content of potatoes for patients with chronic kidney disease” by Sarah Harris, University of Reading March 2018.

8.4. Discussion and recommendations for the agri-food industry

Clear potassium labelling on food would mean that patients with CKD could enjoy convenience food without the worry of accidentally consuming too much potassium. The potassium levels could be made available online and on product packaging. This would make it readily accessible for dietitians and patients to use as a tool. Other consumer groups could also benefit from knowing potassium levels in food, for example, convenience foods for sports enthusiasts.

The simplest way to publish the information about potassium levels would be to add it to the nutritional information used by Nielsen Brandbank™, the digital platform used to manage content for online shopping websites.

Leafy crops such as lettuce also have different levels of potassium depending on variety. Crops that are grown hydroponically could have the levels of potassium manipulated to fit the parameters for consumers with CKD if there is no detriment to the plant.

This project was carried out on potatoes, but any of the crops listed in Figure 30 could be potential candidates for similar projects.

8.5. Conclusion

Peeling and cooking potatoes reduces the potassium level significantly and trial results show that the product would be safe to eat for patients with CKD.

No significant difference was seen in potassium levels between the potatoes from different locations. However, further work is needed to establish if potassium levels <200mg per 100g can be validated throughout the year using different varieties.



This study focused on a specific population group and a problem that had been identified by dietitians. The following chapter focuses on an individual-centred approach to nutrition, how this has emerged and how it could impact the food system in the future.



9. Personalised nutrition: will it drive change?



Figure 29. Nutritional genomics [image courtesy of Mariette Abrahams, RD]

In the beginning of this report I focused on the state of the nation's diet for the UK, in particular levels of fruit and vegetable consumption, and the outcomes of PHE interventions. Generic public health nutrition messages are not working. More-and-more, people are turning to personalised nutrition to deliver solutions for their needs.

9.1. What is personalised nutrition?

The concept of personalised nutrition is not new. It has developed over the last 60 years into the belief that by using an individual's genomic data, nutrition could be used as a tool to manage diet-related chronic diseases (Celis-Morales, 2015).

Nutritional genomics is the study of nutrigenetics which looks at the effect of an individual's genetic makeup on the response to nutrients, and nutrigenomics which is the modulation of gene expression by nutritional compounds (Nutrients, 2015). In summary, personalised nutrition is a staged process where an individual shares information with another party to have tailored nutritional advice.

Established public health messages, such as the Eatwell Guide and “5 fruits and vegetables a day”, were designed for the general population. However, consumers are increasingly looking for personalisation. Companies such as Weight Watchers, recently rebranded as WW, and Slimming World, have arguably been providing tailored nutritional advice for weight loss for many years; but there is an increasing trend in the way we engage with food from weight loss to a focus on health and well-being. Those who want or need more specialist advice are seeking it from apps, software and nutrition professionals.



The chart below shows examples of apps and services that are available to help consumers choose the food that is best for their health, cultural preference or food beliefs. The restaurant Vita Mojo takes this one step further and prepares bespoke meals for their customers.



Figure 30. Personalised nutrition services

Tesco has partnered with the Spoon Guru app to create an online shopping experience for people with specific dietary needs. Spoon Guru has also partnered with AXA PPP Healthcare to offer guidance on food choices to help people reach their health and well-being goals.

9.2. What does personalised nutrition mean for agriculture in the food system?

Personalised nutrition has the potential for behaviour change and subsequently increasing the amount and variety of plant-based foods that people are eating. In order for vegetables to be at the centre of this, it is necessary for the industry to provide convenient solutions that meet the needs of consumers.

Some of the potential opportunities for the food system are listed here:

- An increase in demand for high fibre foods especially sources of prebiotic fibre to satisfy customers wanting to improve gut health.
- A demand for foods grown to enhance desired nutrients.
- Modified supply chains where the traditional route to retail is replaced with supply chains to service an increasing number of smaller and local food and meal kit producers.
- Opportunities for growers to become closer to the consumer because of smaller, agile food businesses focussing on provenance.
- The establishment of low FODMAP diets to manage the symptoms of irritable bowel disease creating an opportunity for more UK grown vegetables such as carrots, leafy greens and potatoes.



- The possibility of food prescriptions driving consumer behaviour down the plant-based foods route and increasing demand for vegetables and fruits.

One of the challenges of growing crops with improved nutritional value will be the higher costs incurred. These will need to be passed on to the product. Although some consumers will be prepared to pay more for a premium product, there are others who will be unable, or choose not to pay the additional costs.

9.3. Recommendations

To facilitate change, a coherent procurement programme across government agencies to buy enhanced-nutrition vegetables at an institution level would be a good place to begin. Other possibilities include: Incentives for food manufacturers and out-of-home caterers to use more nutritious ingredients; and implementation of a personalised nutrition service in the public health system to prescribe healthy diets provided by the private sector.

Eating a more plant-based diet with vegetables high in the nutrients that the population is currently not consuming enough of is not just for the 'worried well', it will benefits everyone.

9.4. Conclusions

PHE has had limited success in changing population eating behaviour through educational messages. Future initiatives need to look at partnerships between the public and private sectors; for example, the integration of a personalised nutrition service into the public health sector but the provision of the prescribed food by the private sector, retail and food service. This could start to have a positive effect on the current food system as people make healthier choices, for example, due to increased focus on gut health and food intolerances.

A personalised nutrition service in the public health system could also help in changing eating habits by including more vegetables, particularly those with higher nutritional quality.



10. Conclusions

The key messages from my Nuffield Farming Scholarship personal study tour “Vegetable production for specific nutritional need” are as follows (in order of the topics discussed):

1. It is accepted that to maintain good health, vegetables are a necessary part the daily diet, and as a nation we need to eat more of them.
2. Public Health Nutrition messages have not been effective in improving consumption of fruit and vegetables over the last 20 years.
3. Vegetables are a key part of the solution to improve low fibre intake. They can also support those with predominantly or exclusively plant-based diets to achieve adequate intakes of vitamin D2, beta-carotene, iron and folate.
4. The level of micronutrients in crops has not reduced with time although changes in plant breeding for increased yield have resulted in a decrease of micronutrients but these are not significant at a human health level.
5. Nutrition-smart Agriculture could be better developed in all countries to improve crop nutritional quality for human health and enhance commercial viability for the agri-food industry.
6. There are range of vegetables that could exploit existing health and nutrition claims:
 - Broccoli – chromium for maintenance of blood glucose
 - Beetroot – betaine and immunity
 - Watercress - immunity and bone health
 - Potato – potassium
 - Mushrooms – vitamin D
7. A combination of branding with an easy to understand health message would help promote the consumption of vegetable products.
8. In general, vegetables need to be positioned for convenience and improve their standing in the food-to-go category. The priority for the consumer is taste and convenience so health claims about nutritional benefits can make a good product more attractive. Beetroot juice is a good example of this.
9. The use of health claims is only one of the tools available to encourage increased consumption of vegetables. Engaging with the plant-based foods community and showcasing vegetable products rich in nutrients and delivered more conveniently, e.g. food to go options, may be key to persuading more consumers to increase their intake of vegetables for health and well-being.
10. Multi-disciplinary collaboration from seed breeders to consumer is crucial to changing the current food system and driving changes in menus for institutions who want to focus on health.
11. Potassium content labelling of foods would be a great start in improving the situation for people with CKD; an effort to analyse potassium levels in crops so that information can be used to help processors would be of further benefit.



12. There is an increase in Personalised Nutrition and the food chain will need to respond to this. The focus is needed on specific population groups who fall outside the public health nutrition guidance, for example, people with CKD.



11. Recommendations

The best time to plant a tree is twenty years ago, the next best time is now.
Chinese proverb

Policy response

1. The primary focus of an integrated food and health policy should be setting a scene of how the food can be used in an everyday context and emphasising how it meets an existing need or solves a problem.
2. Public Health Nutrition should employ personalised nutrition as a tool to enable behaviour change in the population.
3. The opportunity presented by Brexit could be used to develop a set of pre-authorised claims on labelling suitable for fresh produce and easy to communicate to the consumer, e.g. use of logos.
4. Focus initiatives on the key areas where specific vegetables can provide health and nutrition solutions especially with regard to the following vitamins and minerals:
 - a. Fibre
 - b. Vitamin D
 - c. Vitamin A (beta carotene)
 - d. Iron
 - e. Folate
5. Facilitation of nutrition-smart agriculture so that farmers can increase the nutritional value of crops as well as improving productivity and profit.

Industry response

1. Create a platform that brings all elements of the food chain together from seed breeder to consumer.
2. The fresh produce industry needs to explore ways in which an improved economic return can be gained from producing crops with enhanced nutrition.
3. Biofortified or existing vegetables with key properties should be incorporated into processed foods and foods eaten outside of the home.
4. An increased volume of production not only makes the crops more cost efficient but also more accessible to food processors. The benefit of putting the vegetables into the foodservice and prepared foods chain is that the convenience and the enhanced nutrition value of the food can be marketed at the same time.
5. The move towards personalised nutrition will have an impact on the current fresh produce supply chain, therefore growers need to be able to understand the market demands of higher nutrition.



6. The industry needs to speak with government departments to integrate higher nutrition vegetables into the procurement system for public institutions who can then provide higher nutrition foods for their service users.
7. Farmers can be part of the solution to provide the best potassium content in foods for people with CKD. Working together with food manufacturers, retailers and dietitians, from raw to final product, products should be tested and where suitable levels are found, these must be added to specifications and the information made available to consumers *via* online shopping, or on product packaging in stores. If done successfully across sufficient product lines, this could turn the prepared vegetable category into a new destination for these consumers.



12. After my study tour

I applied for a Nuffield Farming Scholarship after a period of hospitalisation stimulated me to think about life's challenges and my attitude to risk.

I enjoy working on challenges where I can find solutions that will benefit others.

I would like to develop the testing and declaration of potassium levels on food with the industry so that people with CKD can benefit from this.

I would also like to work with the vegetable sector to look at how products can be designed to meet the changing needs of consumers now and in the future. The identification of gut health and the low FODMAP diet as a trend is particularly relevant to this sector and I believe the opportunity can be better exploited.

I benefitted hugely from the Global Focus Programme as the 7-week break from my business helped me to re-evaluate and understand the significance of having a business that can operate without me being there and that is also scalable. This has prompted me to look at software solutions for the food supply chain; for example, how they can be used to identify weak points in the chain, and therefore help businesses make better decisions, and prevent food safety issues from developing or reoccurring.

The food and agricultural industry have a recruitment and retention problem that I became more aware of during my international travel. Activities to help and support the next generation of people with good problem-solving skills into the industry are key. In my new role as a director of the Oxford Farming Conference I will have the opportunity to work with young people at the early stage of their careers in food and agriculture.

The research and travel aspect of this project will enable me to strengthen existing relationships with academics and manufacturers, form new relationships, and identify opportunities for future work.



13. Acknowledgments and thanks

I would like to thank my sponsors at The Food Chain who also assisted with my requests for information and made their extensive network available to me.

I was extremely well looked after by Nuffield Farming families, especially Georgie Cartanza in Delaware, the Arvier family in Tasmania during the break in travel between South Korea and New Zealand and Stuart and Angie Wright at the end of my New Zealand trip. I thank my family and friends for their patience during this process and helping me to appreciate what a great opportunity the Nuffield Farming Scholarship is.

My Nuffield Farming mentor, Rob Ward, was a constant source of inspiration and his unique ability to help me push through the difficult times will always be appreciated.

I am very grateful to have received financial support from Fruitnet Media and The Nutrition Society to attend conferences

The Nuffield Farming Trust Mike and Poey Vacher, Louise Manning, Alison Blackburn, Ali Capper, Jack Ward and all the scholars who helped me to find contacts and made introductions:

The United Kingdom:

Professor Carol Wagstaff, Sarah Harris, University of Reading
 Adrian Cunningham, Maureen Strong, AHDB
 Professor Chris Elliot, QUB
 Duncan Worth, Simon Day, Will Dickson and Ed Palmer, AH Worth
 Chris White, Fruitnet Media
 Richard Tudor, Elsoms Seeds
 Dr Tina Barsby, NIAB
 Jonathon Oxley, Stephen Oyston N8 Agri-food
 Jim Godfrey, Alex Godfrey, RJ and AE Godfrey
 Lorna Friss, BBSRC
 Rhiaz Bhunnoo, Global Food Security Programme
 Mark Hanes and Graham Forber, G's
 Guy Faulkner, Agrimarkets
 Ollie Bedford, The Watercress Company
 Judith Batchelar and Beth Hart, Sainsbury's
 Diane Robinson, Chris Hurley, Bakkavor UK
 Sharon Macgregor, Monsanto
 Dyno Keatinge, ex-director World Vegetable Centre
 Professor Ray Winger
 Dr Kirsten Brandt, Professor John Mathers, University of Newcastle
 Asmma Shariff, Khalid Mahmood, Rothamsted
 Adrian Barlow
 Tunde Dazco, Storm Strategy
 Andrew Burgess, Produce World
 David Barney, Geofresh
 Karen Davies, University of Nottingham
 Ian Marber, Independent nutrition consultant
 Deepa Kariyawasam, Kings College Hospital



Professor Martin Hall, Campden BRI
Jo Oliver, Marks and Spencer
Richard Mussett, McCain UK
Susan Church, Susan Church Nutrition
Dr. Katie Heath, Science writer
Dr. Jo Kilner, Science writer

The Netherlands:

Edward Vonk, Banken Mushrooms
Bauke van Lenteren, Mathilde Tournebize, Rijk Zwaan

France:

Séverine Mouchel, Dietician

Portugal:

Mariette Abrahams, Dietician

USA:

Scott Farms
Professor Rita Landgraf, Assoc. Prof Alison Karpyn, University of Delaware
Cheryl Ducette, Nancy Mears, Georgie Cartanza University of Delaware extension service
Ed Key, Nuffield Farming USA

China:

Franck Platt, Richard Miller, David Grant, Bakkavor China
Nicola Aporti, HFG Law China
Freya Tang, Oliver Davies, S&A Produce
John Kim, Lee & Co
Mabel Zhuang MZ Marketing Communications
Wendy Wang

South Korea:

Taewon Um, Inwah Lee, Sungji Moon, Ms Seo, BCKK
Dr. Cho-il Kim, Korea Health Industry Development Institute
Lewis Patterson, At Latitude
Yoojin Jung
Hyeon Young-Park
Mr Oh, Nonghyeop

Australia:

John Hey, Asiafruit
Dr Hazel Mactavish-West
Aleisha Deane, APD
Richard Bennett, PMA
The Arvier family

New Zealand:



Carolyn Lister, Claire Hall, Christian Pena, Marion Mackenzie, Liverpool Zhang, Plant and Food Research
Donnell Alexander, MPI
Michael Whitaker, Te Mata Mushrooms
Melanie Rushton, Meadow Mushrooms
Chris Claridge, Kate Underwood, Potatoes NZ
Jerry Prendergast, MM Marketing
Lisa Cork, Fresh Marketing
Dayna Stuart
Paula Dudley 5+ A Day NZ
Dr Juliet Ansell, Zespri
Stuart and Angie Wright

Barbara Bray



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Appendix 1. The Power of Vegetables

This appendix outlines information from research to demonstrate that certain vegetables provide a range of key nutrients that are lacking in the average UK diet, specifically, fibre, iron, vitamin D, vitamin A (retinol) and folate. It also describes the roles that these nutrients provide in the body.

These five key vitamins and nutrients have been identified as below optimum in the UK population in the latest NDNS survey; however, the UK is not alone in having a population with low consumption of important nutrients.

Numerous academic texts provide comprehensive information on of these nutrients and their potential benefits. Furthermore, all are available in vegetables grown in the UK at sufficient levels to meet current dietary guidelines. The following list gives examples:

1. Fibre: Skin on potatoes; leafy greens and legumes;
2. Iron: Broccoli; Leafy greens;
3. Vitamin D: Vitamin D2 enhanced mushrooms
4. Vitamin A (beta carotene): Spinach; red pepper; red cabbage; carrots
5. Folate: Leafy greens, e.g. watercress; spinach; rocket

Fibre

There is increasing awareness on the importance of gut health with research showing that the functioning of the gastrointestinal tract affects the body's entire wellbeing. Fibre is essential for the normal functioning of the gut. It is also associated with a reduced risk of chronic diseases such as cardiovascular disease, type 2 diabetes and bowel cancer.

Figure 33 lists vegetables that contain high levels of fibre (AOAC, the internationally recognised voluntary method of analysis).

| Vegetable | Fibre (in grams) per 100g AOAC edible portion |
|-------------------------------------|---|
| Old potatoes, cooked skin on wedges | 3 |
| Chips, fine cut | 3.8 |
| New potatoes boiled with skin | 1.8 |
| Green beans boiled | 4.1 |
| Raw peas | 5.3 |
| Broccoli steamed | 3.8 |
| Sweetcorn 'on-the-cob' boiled | 5.1 |

Figure 31. Fibre content in selected vegetables [McCance and Widdowson's *The Composition of Foods 7th Summary Edition*]



In food labelling, a source of fibre is defined as the product containing at least 3g fibre per 100g; and high in fibre where the product contains at least 6g fibre per 100g

The Australians actively encourage their population to increase their fibre intake and have specific recommendations for male and females, as illustrated below.



Figure 32. Fibre infographic [Aleisha Deane, APD, Australia]

Prebiotics are recognised and marketed as a specific group of fibres that can stimulate the growth of beneficial bacteria in the gut (Dimidi, 2017). It is also termed as ‘resistant starch’ and is found in starchy foods (Fuentes-Zaragoza, 2011). As such, many vegetables are classed as a source of prebiotics. The food-to-go sector is starting to recognise this by incorporating more vegetables into ‘gut healthy’ meals. The fast food chain LEON is one example.



The “Feel Sunny Inside” gut campaign is a partnership between Leon restaurants and the gut-health expert and dietician, Dr Megan Rossi of Kings College London.

Its focus is to celebrate foods which support good gut-health through the brand’s ethos of “eating well is key to living well, and good gut health makes for a wellbeing”.

Figure 335. Leon restaurants [image leon.co]

Iron

Iron is essential for maintaining a healthy immune system; however 48% of girls aged 11–18, and 27% of women aged 19–64 have iron levels below the Lower Reference Nutrient Intakes (LRNI) recommendation. Animal-based diets provide the highest and most bioavailable sources of iron; however, with the increase in plant-based diets, the need to identify and publish plant-based sources of iron, particularly for females, is becoming more urgent.

Vitamin D

Vitamin D is important for bone health, skeletal and heart muscle health, and regulation of insulin, blood sugar and the immune response (NHS Choices, 2017); however, NDNS figures show that the UK population is largely deficient in vitamin D. The human body synthesises vitamin D when the skin is exposed to sunlight but increasing use of sun screen and covering the body is increasing the importance of plant-based sources of this vitamin.

Mushrooms are a natural source of ergosterol (provitamin D2), which can be converted into vitamin D2 by exposure to UV light (sunlight). Mushroom growers use this technique to enhance the content of vitamin D2 in mushrooms.

Vitamin A (retinol)

Among its other roles, Vitamin A supports the body’s immune system against illness and infection, and helps improve vision in poor light (NHS Choices, 2017). It also promotes healthy skin cell production. Plants and vegetables provide beta-carotene, the precursor to Vitamin A, which is then converted to retinol in the intestinal wall.



Folate

Folate (vitamin B9 or folic acid) is used in the synthesis of DNA and thus the production and maintenance of new cells, including red blood cells. Insufficient levels of folate can lead to folate-deficiency anaemia (National Diet and Nutrition Survey, 2017).

In the UK a substantial proportion of adolescents and women of child bearing age are deficient in folate. This is of particular concern because the folate requirement increases during pregnancy. It is difficult to reach the necessary amount through diet alone, therefore women are advised to take supplements (British Nutrition Foundation, 2015). Fortification of cereals is also common. The best plant-based dietary sources of folate are listed below.

| Vegetable | Folate (in grams) per 100g AOAC edible portion |
|------------------|---|
| Watercress | 45 |
| Baby raw Spinach | 161 |
| Rocket | 88 |
| Blueberries | 8 |
| Strawberries | 61 |

Figure 36. Folate content in selected vegetables and fruits
[McCance and Widdowson's *The Composition of Foods 7th Summary Edition*]

With the increasing popularity of plant-based diets, opportunities to market products based on combinations of spinach, watercress and rocket to this population group could be explored; for example, the use of health claims such as “folate contributes to maternal tissue growth during pregnancy” on relevant food items that are popular with this population group.

Conclusion

Currently there is an emphasis in the UK to improve vegetable consumption by using initiatives to make “the healthy choice the easy choice”.

The use of health claims is only one of the tools available to encourage increased consumption of vegetables. Engaging with specific target groups, e.g. the plant-based foods community, and showcasing vegetable products rich in these nutrients that can be delivered more conveniently, such as food-to-go options, may be a key step towards persuading more consumers to increase their intake of vegetables for health and well-being.

In addition, explaining the benefits of nutrients to consumers is often best achieved in terms of a desired outcome. For example, teenagers would be attracted to vegetables advertised as helping solve skin problems, rather than a message telling them to ‘eat more vegetables’!

978-1-912059-90-4



Published by Nuffield Farming Scholarships Trust
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