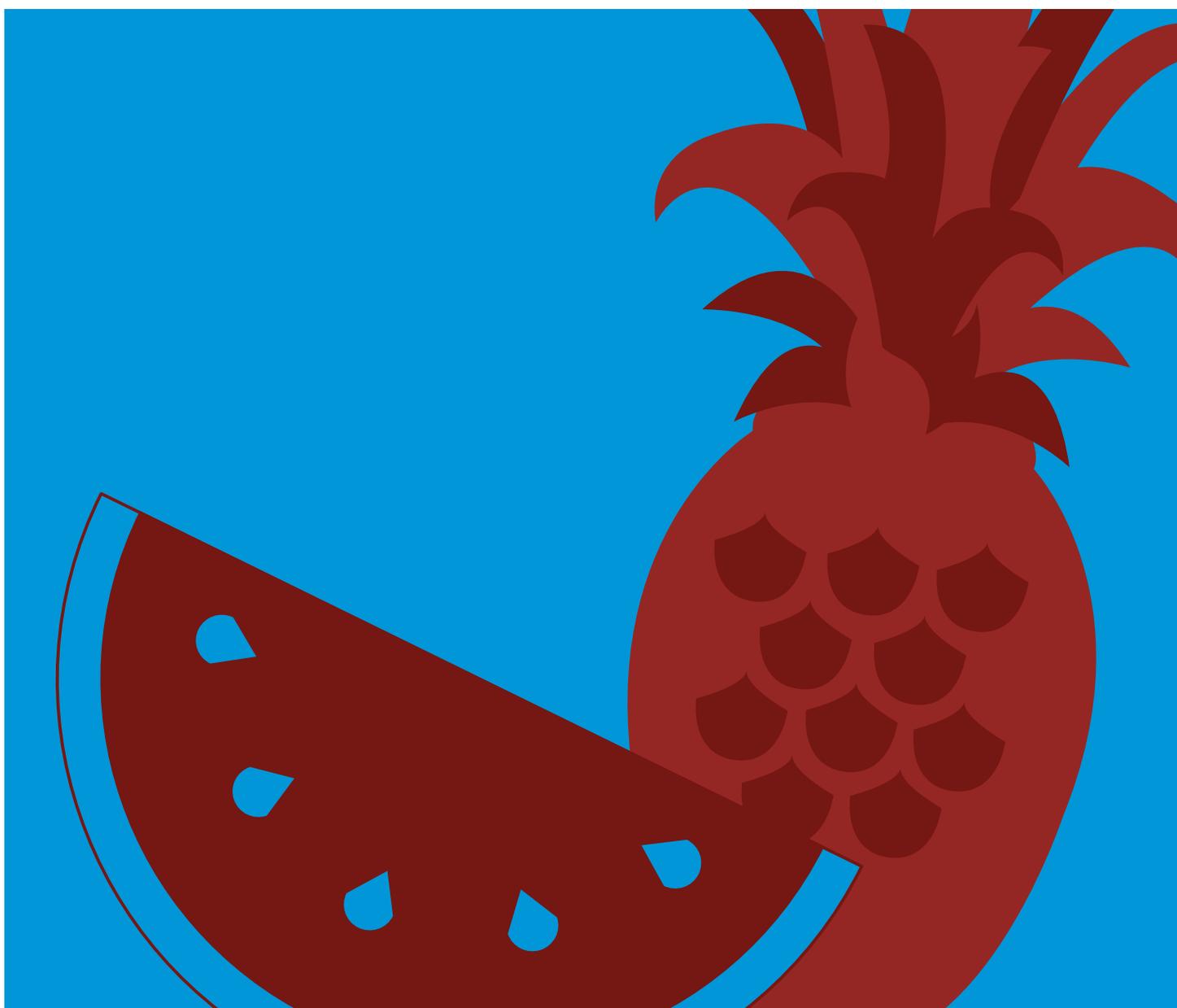


A Review of the Fruit and Vegetable Food Chain



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Table of Contents

Acknowledgements	1
Members of the External Advisory Group	1
List of Tables	5
List of Figures	5
Abbreviations	6
Executive Summary	7
Chapter 1 Introduction	12
1.1 Background to safe food	12
1.2 Objective and Terms of Reference of the Reviews	12
1.3 Consumer Focused Review of Fruit and Vegetables	13
1.3.1 <i>Introduction</i>	13
1.3.2 <i>Scope of the Review</i>	13
1.3.3 <i>Food Safety Risks in Fruit and Vegetables from a Consumer Perspective</i>	14
Chapter 2 The Supply Chain	19
2.1 Introduction	19
2.2 The Global Supply Chain	19
2.3 The European Context	19
2.3.1 <i>Production</i>	19
2.3.2 <i>Imports</i>	20
2.3.3 <i>Exports</i>	20
2.4 Island of Ireland	21
2.4.1 <i>Introduction</i>	21
2.4.2 <i>Production</i>	22
2.4.3 <i>Imports</i>	23
2.4.4 <i>Exports</i>	24
2.4.5 <i>The Organic Market</i>	24
2.4.6 <i>Retail</i>	24
2.4.7 <i>Food Service</i>	25
2.4.8 <i>Processing</i>	26
Chapter 3 Food Safety	27
3.1 Introduction	27
3.2 Microbiology	27
3.2.1 <i>Introduction</i>	27
3.2.2 <i>Foodborne Human Infections Associated with Fresh Produce</i>	28
3.2.3 <i>Preventing Microbial Contamination along the Food Chain</i>	35
3.2.4 <i>Sprouted Seeds</i>	40
3.2.5 <i>Spoilage</i>	41
3.2.6 <i>Food Safety Regulation of the Fruit and Vegetable Supply Chain</i>	41
3.2.7 <i>Codes of Practice and Guidelines</i>	42
3.3 Chemical Residues and Contamination	43

3.3.1	<i>Introduction</i>	43
3.3.2	<i>Residues Resulting from Deliberate Pre-Harvest Chemical Treatments</i>	43
3.3.3	<i>Residues Resulting from Deliberate Post-Harvest Chemical Treatments</i>	47
3.3.4	<i>Unintentional Contamination</i>	50
3.4	Third Country Import Controls	50
3.4.1	<i>European Commission, Food and Veterinary Office</i>	51
3.4.2	<i>Border Inspection Posts</i>	51
3.5	Product Traceability and Recall	52
3.5.1	<i>Product Traceability</i>	52
3.5.2	<i>Product Recall</i>	53
Chapter 4 Nutrition		
4.1	Introduction	54
4.2	Nutritional Composition of Fruit and Vegetables	54
4.3	Effects of Processing and Cooking on Nutritional Composition	55
4.3.1	<i>Preservation Methods</i>	55
4.3.2	<i>Preparation Methods</i>	57
4.3.3	<i>Cooking Methods</i>	58
4.4	Dietary Composition Patterns	59
4.4.1	<i>Current Consumption of Fruit and Vegetables on IOI</i>	59
4.5	Contribution of Fruit and Vegetables to Nutrient Intake	60
4.6	Patterns of Consumption	61
Chapter 5 Health Benefits		
5.1	Introduction	62
5.2	Cardiovascular Disease	62
5.3	Cancer	63
5.4	Diabetes	64
5.5	Osteoporosis	65
5.6	Overweight and Obesity	66
5.7	Perceptions and Barriers to Change	66
5.7.1	<i>Access and Availability</i>	66
5.7.2	<i>Attitudes and Behaviour</i>	67
5.8	Initiatives to Increase Fruit and Vegetables Consumption on IOI	67
5.8.1	Northern Ireland	67
5.8.2	Republic of Ireland	67
Chapter 6 General		
6.1	Introduction	69
6.2	Labelling	69
6.2.1	<i>General Food Labelling Requirements</i>	69
6.2.2	<i>Specific Fruit and Vegetable Labelling Requirements</i>	69
6.2.3	<i>Nutrition Labelling</i>	71
6.3	Quality Assurance Schemes	71
6.3.1	<i>Bord Bia Quality Assurance Scheme</i>	71
6.3.2	<i>Assured Produce Scheme</i>	72
6.4	Training	73

6.4.1	<i>Northern Ireland</i>	73
6.4.2	<i>Republic of Ireland</i>	73
6.5	Organic Produce	73
6.5.1	Production Requirements	73
6.5.2	Labelling Requirements	74
6.5.3	Food Safety and Nutrition Aspects of Organic Produce	74
6.5.4	Monitoring of Organic Fruit and Vegetables	74
6.5.5	Authenticity	74
6.6	Genetic Modification	75

Chapter 7 Conclusions

7.1	Introduction	76
7.2	Conclusions	76
7.2.1	<i>Primary Producers and Packers</i>	76
7.2.2	<i>Processors and Distributors</i>	77
7.2.3	<i>Retailers and Caterers</i>	77
7.2.4	<i>Consumers</i>	78
7.2.5	<i>Health Professionals</i>	79

Appendices

A	Examples of portion sizes of fruit and vegetables	80
B	Climate types for fruit and vegetables	83
C	Leading suppliers of fruit and vegetables to the EU	84
D	The Hygiene Package	84
E	Nutritional composition of different classes of fruit and vegetables	85
F	Mean daily intake of vegetables (excluding potatoes) in Irish men and women aged 18 to 64 years	86
G	Mean daily intake of fruit in Irish men and women aged 18 to 64 years	87
H	Percentage of individuals complying with the current UK and ROI recommendation of five or more portions of fruit and vegetables per day and the USDA's recommendation of three portions of vegetables and \geq two portions of fruit per day	87
I	Intake of fruit and vegetables among 5 to 12 year olds in the National Children's Survey	88
J	Contribution of fruit and vegetables to nutrient intakes in adults on IOI and primary school children in ROI	89
K	Quality Class	90
L	Organic certification bodies on IOI	90

Glossary	91
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References	92
-------------------	-----------

List of Tables

Table 1.1	Issues of concern to consumers about the production, preparation and consumption of fruit and salad vegetables	14
Table 1.2	Prompted issues of concerned consumers about the production preparation and consumption of fruit and salad vegetables	14
Table 1.3	Percentage of consumers who reported that the following mechanisms were effective at assuring them of the safety of the product indicators of quality and safety produce	14
Table 1.4	No. of portions of fruit and vegetables consumers think a person should eat daily	15
Table 1.5	Consumer perception of portion size	15
Table 1.6	Advantages and disadvantages of different forms of fruit and vegetables	16
Table 1.7	Triggers and barriers behind fruit and vegetable consumption	17
Table 1.8	Perceptions of organic produce	18
Table 2.1	EU Production of fruit and vegetables	20
Table 2.2	Horticulture clusters on IOI	22
Table 2.3	Farm gate production value of fruit and vegetables on IOI	22
Table 2.4	Retail value of vegetables 2005 (ROI)	24
Table 2.4	Retail value of fruit 2005 (ROI)	25
Table 2.6	Prepared chilled produce market share 2005 (ROI)	25
Table 3.1	Estimated annual impact of indigenous foodborne disease, by selected food group and type, England and Wales	29
Table 3.2	Estimated annual healthcare impact of indigenous foodborne disease, by selected food group and type, England and Wales	30
Table 3.3	Estimated risks associated with food groups and type, England and Wales	30
Table 3.4	Pathogens transmitted via fruit and vegetables	32
Table 6.1	Fresh fruit and vegetables subject to EC marketing standards	69
Table 6.2	Other legislation pertaining to the marketing of fresh fruit and vegetables	71
Table 6.3	EU legislation relating to genetically–modified food	75

List of Figures

Figure 2.1	Fruit and vegetable supply chain on IOI	21
Figure 3.1	USA vehicles of produce-related outbreaks, 1990 to 2003	31
Figure 3.2	Typical flow diagram for the production of minimally processed vegetables	37
Figure 3.3	Decontamination techniques	38
Figure 6.1	Information required on the label	70

Abbreviations

ADI	Acceptable Daily Intake
AICR	American Institute for Cancer Research
ARfD	Acute Reference Dose
BIP	Border Inspection Post
CAP	Controlled Atmosphere Packaging
CDC	Centre for Disease Control
CDSC	Communicable Disease Surveillance Centre
CFU	Colony Forming Unit
COPR	Control of Pesticides Regulations

COT	Committee on Toxicity
CSPI	Centre for Science in the Public Interest
CVD	Cardiovascular Disease
DAF	Department of Agriculture and Food
DARD	Department of Agriculture and Rural Development
DEFRA	Department for Environment, Food and Rural Affairs
EFSA	European Food Safety Authority
EH	Oxidation Reduction
EHO	Environmental Health Officer
EPA	Environmental Protection Agency
EPIC	European Prospective Study of Cancer
FAO	Food and Agricultural Organisation
FDA	Food and Drug Administration
FSA	Food Standards Agency
FSAI	Food Safety Authority of Ireland
FSTC	Food Safety Training Council
FTE	Full Time Equivalent
FVO	Food and Veterinary Office
GAP	Good Agricultural Practice
GM	Genetically-Modified
GMP	Good Manufacturing Practice
GRAS	Generally Recognised As Safe
HACCP	Hazard Analysis Critical Control Point
HPSC	Health Protection Surveillance Centre
HSE	Health Service Executive
IAEA	International Atomic Energy Agency
IOI	Island of Ireland
JECFA	Joint FAO/WHO Expert Committee on Food Additives
MAP	Modified Atmosphere Packaging
MRL	Maximum Residue Level
MS	Member State(s)
MTDI	Maximum Tolerable Daily Intake
NI	Northern Ireland
NSIFCS	North-South Ireland Food Consumption Survey
NSP	Non Starch Polysaccharides
PCS	Pesticide Control Service
PPPR	Plant Protection Products Regulations
PRC	Pesticide Residues Committee
PSD	Pesticide Safety Directorate
RASFF	Rapid Alert System for Food and Feed
ROI	Republic of Ireland
RTE	Ready-to-eat
SCF	Scientific Committee on Food
SCFA	Standing Committee on the Food Chain and Animal Health
SLAN	Survey of Lifestyle, Attitudes and Nutrition
USDA	United States Department of Agriculture
WCRF	World Cancer Research Fund
WHO	World Health Organisation

Executive Summary

In 2005 **safefood** initiated a programme which involves two comprehensive food chain screening exercises per year over a three year period. Each review profiles a specific food category, identifies and describes the relevant food safety issues pertaining to it at various points along the food chain, and identifies opportunities to communicate the human health benefits to, and influence the behaviour of, the various stakeholders. The primary focus of these reviews is directly pertaining to food safety and nutrition issues. However, other concerns identified by consumers not directly related to food safety are discussed, e.g. labelling, quality assurance schemes, and training, etc.

Both quantitative and qualitative research conducted on behalf of **safefood** indicates that consumers are well informed about the health benefits of a diet rich in fruit and vegetables and the recommendations that five portions should be consumed on a daily basis. Nevertheless, intake levels on the island of Ireland remain low, particularly amongst adult men; children; and socially disadvantaged groups. Less well recognised is the potential risk of infectious disease from fruit and vegetables.

As an island with an agricultural tradition, the horticulture food sector remains a valuable contributor to Northern Ireland economies of both Republic of Ireland (ROI) and Northern Ireland (NI). Figures from ROI indicate that after dairy and beef, horticulture is the most valuable sector in agriculture. IOI is, in the main, largely self sufficient in most fruit and vegetables, except for those produce grown in warmer climates and those dependent on seasonality. The only major export from IOI is mushrooms, which while still significant in terms of quantity has dropped in value in recent years.

A high intake of fruit and vegetables in the diet is positively associated with the prevention of cardiovascular disease; cancer; diabetes; and osteoporosis. There is also convincing evidence that a high dietary intake of fibre (most specifically Non Starch Polysaccharides (NSP) is a factor in protecting against weight gain and obesity as well as being an effective weight loss strategy. The World Health Organisation (WHO) advocates a daily intake of 400g of fruit and vegetables for health (this is equivalent to approximately five portions based on an average weight of 80g per portion).

Fruit and vegetables are described as 'low energy-dense foods relatively rich in vitamins, minerals and other bioactive compounds as well as being a good source of fibre'. The main nutrients attributable to fruit and vegetables in varying amounts include vitamins C and E; folate; selenium; zinc; and NSP. While fruit and vegetables are a poor source of protein, they are also low in fat and energy. Nevertheless, the overall health promoting profile of this food category may be compromised by preparation and cooking methods such as pickling and frying. The addition of fat based accompaniments such as sauces and creams can also impact on the profile, while preservation methods such as canning can increase the salt or sugar content. Other methods of preservation such as freezing, however, can actually maintain the nutritional quality.

In spite of the strong evidence of health benefits, and the reported awareness of these benefits, intakes of fruit and vegetables on the IOI are low. The North South Ireland Food Consumption Survey indicated that intake of fruit and vegetables among adults aged 18 to 64 years on IOI was 136g/d and 140g/d, respectively, approximately equivalent to 3.5 portions of total fruit and vegetables per day. Age had a significant effect on the consumption of fruit and vegetables with younger people (18 to 45 years) consuming 114 g/d and 128 g/d, respectively. Significantly, composite meals were shown to be a major contributor to vegetable intake.

Intake amongst children and young people on IOI is also low. A Health Promotion Agency study in 2001 reported that one in five boys and one in eight girls in NI aged five to 17 years did not eat any fruit and vegetables on a daily basis. In 2005 the National Children's Study in ROI revealed similar results with average intake of vegetables equivalent to a little more than half a portion per day. Fruit intake was equivalent to nearly two portions per day but more than half of this fruit intake was made up of fruit juice.

Research conducted on the barriers to consumption of fruit and vegetables has indicated that attitudes, motivation and skills in buying, preparing and eating fruit and vegetables all impact. Access and availability to good quality produce is also cited. During **safe food** qualitative research participants identified cost as a barrier to consumption, in particular for those who bought large quantities. This barrier is further amplified in lower socio-economic groups. Other barriers identified during the discussion groups included the perceived short shelf life of certain fruit and vegetables; the inconvenience of preparation of some fruit and vegetables; and the quality (and ripeness) of produce was seen to be 'hit and miss' thus discouraging consumers from purchasing these items.

Fruit and vegetables are increasingly being recognised as an emerging vehicle for foodborne illness in humans. Traditionally meat, milk and egg products were the 'usual suspects'. However, the consumption of fresh produce (fruit and vegetables) is linked, both epidemiologically and microbiologically to infectious intestinal disease. Nevertheless, this represents only a small proportion of the total number of reported cases.

There are some features associated with fresh produce acting as vehicles of infection that should be noted: contamination often occurs early in the production process, e.g. via animal manure or contaminated water used during growth or harvesting; ingredients from many countries may be combined in a single dish making the specific source of contamination difficult to trace; fresh produce foods typically have fewer barriers to microbial growth such as salt, sugars or preservatives.

Pathogens most commonly associated with fruit and vegetables include *Salmonella*, *Shigella*, *E. coli* 0157, *Listeria*, *Campylobacter*, *Cryptosporidia* and viruses such as Hepatitis A. One of the most commonly cited sources of outbreaks of food poisoning associated with fresh produce, is the contamination of lettuce with *Salmonella* spp.

There are a number of sources of microbial contamination, all of which must be controlled. The key areas where contamination can occur are in the field; during harvesting and processing; and in the home. Steps to limit contamination and prevent spread of microorganisms are described in the report.

Fruit and vegetables are prone to chemical contamination from a variety of sources. This can occur under growing, harvesting or post-harvest conditions and can result from deliberate exposures, such as pesticide application, or unintentional exposures, such as those resulting from fungal contamination.

The application of all chemicals added to fruit and vegetables and levels of residues are controlled and monitored carefully by the competent authorities in NI and ROI. In 2004, 3.4 percent of samples tested in ROI breached the MRL (maximum residue level) for certain pesticide residues. However, as the acceptable daily intake (ADI) for the pesticides was not exceeded, the breach was not considered a public health concern. In the UK (including NI) the monitoring programme for nitrate in fruit and vegetables for 2005, recorded levels which were generally low and considered not to represent a safety concern based on the established ADI. There are similarly no current concerns regarding the levels of other chemicals such as chlorine, ozone or quarternary ammonium compounds.

The organic sector is a growing market, particularly within the fruit and vegetables area. The sector is highly regulated with farmers, growers, processors and importers having to undergo a stringent inspection process before being licensed. Organic products are sought after by consumers in the belief that they are safer and more nutritious than conventionally grown foods. However, the evidence remains unclear on this matter and the decision to purchase and consume organic foods is seen as a lifestyle choice.

Genetic modification (GM) can offer the opportunity to produce more vigorous crops with higher yields. It can also be used to confer herbicide tolerance, virus resistance, delayed ripening and other traits into plants for food use. Ingredients from maize, soya bean and oilseed rape are the most common types of GM foods on the EU market. In spite of the potential uses of GM crops and the safety assertions from regulatory and health bodies, some consumers in Europe remain strongly opposed to their use in food or placement on the market.

This review has collated and considered the information available – academic, regulatory, public health – on the safety and health implications of raw vegetables and fruit. On the basis of the evidence the review draws the following conclusions, which may provide the basis for action for **safe food** and other agencies on the island, as well as for stakeholders, public health professionals and consumers.

Conclusions

Primary Producers and Packers

- Many food pathogens are commonly found in soil where the edible portion of vegetables are grown either directly in soil (root vegetables) or in close proximity to the soil (leafy vegetables), thus creating potential for direct contamination during growing. While recognising that the total elimination of the risk of soilborne contamination may be impossible, thorough washing prior to packaging should serve to remove as much soil as possible.
- With respect to fruit products, these can be contaminated via soil if the fruit has dropped from trees. The practice of using dropped or fallen fruit should be avoided, as the produce may have become bruised or the skin may have been broken, allowing internalisation of bacteria.
- Transmission of pathogens can occur directly from animals, birds and insects. Many animals can act as reservoirs for human pathogens and if these animals come into contact with fresh produce, contamination can occur. Animals should be prevented from entering fields and measures should be taken to prevent animal waste contaminating crop fields or water supplies particularly during heavy rainfall.
- Where organic material such as manure is being used as fertiliser, there are guidelines for growers which aim to minimise the risks of microbiological contamination of RTE crops. These guidelines should be followed to prevent contamination with potentially dangerous bacteria such as *E.coli* 0157:H7.
- Growers should identify the sources of water used for a particular purpose and minimise contamination from livestock, run-off, heavy rainfall and excess irrigation. It is also recommended that the microbial and chemical quality of the water is tested at appropriate intervals. Potable or clean water should be used.
- Field worker hygiene is important as hands are used in much of the harvesting process. Thus, the importance of personal hygiene should be stressed.
- To prevent cross-contamination during harvesting, thorough cleaning and decontamination of equipment, containers and transport vehicles should be undertaken.

Processor and Distributors

- It is important that hygienic practices are followed throughout the processing of fresh produce and that raw materials and finished product are stored and handled in such a manner as to prevent contamination and damage which may lead to internalisation of organisms.
- The temperature used during processing should be controlled to prevent product spoilage and also to prevent the growth of pathogens.
- Worker hygiene is central in the prevention of cross-contamination.
- During trimming and peeling:
 - The edible portions should be conveyed to a segregated, hygienic, temperature controlled area within ten minutes for further processing.
 - To prevent structural damage, the peeling process should be as gentle as possible. Manual peeling causes less damage but this is not always an economically viable option. The use of a knife blade is recommended as it will cause less damage.
 - Peeling and other machinery should be thoroughly cleaned and disinfected regularly to avoid microbial build up, growth and subsequent contamination of the produce.
- Some produce items with a higher water content, e.g. unwaxed apples, celery and tomatoes, are susceptible to

microorganisms entering the skin via the stomata and through stem scars on the calyces of fruits, or through damage to the skin. Surface washing will not wash these internalised bacteria thus the wash water should be maintained 10°C above the temperature of the produce.

- Following decontamination with chlorine a final washing step should be included with non-chlorinated rinse water that has been chilled to 1°C to 2°C. This step will remove traces of chlorine and reduce the product temperature to 5°C, thus increasing its shelf-life.
- The development of technologies such as Modified Atmosphere Packaging (MAP) and Controlled Atmosphere Packaging (CAP), used to extend shelf-life, are of great economic importance to the fresh produce industry and the resulting products popular with the consumer because of their convenience. However, MAP alone is not sufficient to prevent pathogen growth, chilling at 5°C or less is essential, while Hazard Analysis Critical Control Point (HACCP), Good Manufacturing Practice (GMP) and Good Agricultural Practice (GAP) should be in place to prevent pathogen contamination throughout the supply chain.
- Staff suffering from gastrointestinal conditions should be required to report their condition to their employer, be excluded from handling food and required to seek medical advice before being allowed to return to their duties. It is the employers' responsibility to ensure that this is adhered to.
- The requirement for suitable sanitary conditions, such as adequate hand washing facilities, at all stages within the food production chain, including primary production is at the core of ensuring safe fruit and vegetables for the consumer.
- Processing of fruit and vegetables will influence the nutritional value of the final product. This is particularly important for processes that involve the addition of heat as heat sensitive micro-nutrients will be most affected. It is also relevant to the addition of water and ingredients such as salt and sugar.
- Not only will the chill chain ensure the safety of fruit and vegetables, cool temperatures are an effective method of retaining the nutritional value of fruit and vegetables.

Retailers and Caterers

- The retailer and caterer represent the front line of the food industry to consumers. Therefore, both sectors must do all within their powers to take the appropriate steps of ensuring food safety.
- Worker hygiene and hygienic practices are central in the prevention of cross-contamination.
- HACCP and training are at the core of good food safety practice. The influx of foreign-nationals into IOI, and their uptake, in large numbers, of employment within the food sector, has put even more emphasis on the need for training, including that within their native languages.
- Cooking is a necessary part of making many fruits and vegetables edible. The use of excessive water and heat should be avoided to retain the micronutrient composition and methods such as microwaving and steaming should be considered. Overcooking and storage over long periods should be avoided.
- The nutritional content of fruit and vegetables can be altered appreciably by the addition of ingredients such as sugar, creams, sauces and salad dressings. In some cases this can turn a low energy food into an energy dense food. Consumers should be offered the choice of adding these ingredients themselves.

Consumers

- Raw fruit and vegetables are highly nutritious. They are a low energy dense and fibre rich food source in the diet offering a diverse range of micronutrients. Variety in choosing fruit and vegetables is important in obtaining the full benefits of the nutrients found in the different types.

- Aim for at least five portions a day (400g/day), including tinned, frozen and dried varieties.
 - Juice, while it does count towards a portion, is not a replacement for raw fruit and vegetables as it does not have fibre to the same extent.
 - Smoothies (mash/pulp) are nearer to raw fruit and vegetables than juice and therefore a good option.
- Cooking is a necessary part of making many fruit and vegetables edible. The use of excessive water and heat should be avoided to retain the micronutrient composition, and methods such as microwaving and steaming should be considered.
- The addition of ingredients to fruit and vegetables, such as sugar, creams and sauces can alter the nutritional content. When purchasing processed fruit and vegetable products avoid those that have additional salt, sugar and fat added. In the home the use of low-fat alternatives to cream such as yogurt and crème fraîche and the avoidance of salt during cooking are recommended. Alternatives to salt during cooking include lemon juice, garlic, ginger, pepper, and herbs and spices.
- There should be an emphasis placed on the importance of reading labels of prepared and/or Ready-to-Eat (RTE) fruit and vegetables.
- RTE fruit and vegetables are eaten in their raw, uncooked form and it is thus essential that these commodities are free from contamination. Washing or peeling of fruit and vegetables is not required as a protection against pesticide residues; however, it is sensible to wash fruit and vegetables before consumption for reasons of general food hygiene. The most efficient method is to rub or brush fresh produce under cold running tap water.
- Pre-packed vegetables in MAP or CAP are safe to eat and should be stored at 5°C.
- It is not necessary to store non-prepackaged fruit at refrigerated temperatures; however, fruit and vegetables stored at room temperature have been shown to lose some of their nutritional value more quickly compared to those which have been stored under refrigeration. Unripe bananas should not be stored in a refrigerator as this interrupts the ripening cycle and thus should be left at room temperature.
- There is potential for contamination from raw meat and poultry to RTE fruit and vegetables. Therefore, it is essential that all steps are taken during food storage and preparation to prevent such cross-contamination from taking place. This includes:
 - washing hands before food preparation and after handling raw meat and poultry, and
 - keeping raw and RTE foods completely separate by adequately decontaminating utensils and cutting boards between use.

Health Professionals

- In spite of the claimed knowledge of the Five-a-Day message, intakes of fruit and vegetables on IOI remain low. Therefore, there is a need to continue to promote this message, particularly amongst children and younger people, and clarify uncertainties such as the definition of portion sizes, as well as raising awareness of the health benefits of fruit and vegetables.
- Within promotional activities the barriers to consumption, such as accessibility to fresh fruit and vegetables (particularly amongst lower socio-economic groups) and attitudes and awareness should be addressed. This requires a multi-strategic approach.

1. Introduction

1.1 Background to safefood

safefood espouses a vision of an environment where consumers have confidence in the food they eat. In order to create this environment, **safefood** works in close collaboration with its partners in food safety and nutrition; and seeks to add value, rather than duplicate their work.

The role of **safefood** is determined by its governing legislation, which sets out its functions. These functions are summarised as follows:

- Promotion of food safety
- Research into food safety
- Communication of food alerts
- Surveillance of foodborne disease
- Promotion of scientific co-operation and linkages between laboratories
- Development of cost-effective facilities for specialised laboratory testing

safefood's functions also include the provision of independent science-based assessment of the food chain and the organisation has a role in giving advice on the nutritional aspects of foods.

1.2 Objective and Terms of Reference of the Reviews

In order to address in part its function in relation to carrying out independent science-based assessment of the food chain, as well as adopting the theme of complementary working and added value, in 2005 **safefood** initiated a programme which involves two comprehensive food chain screening exercises each year until 2007. Each review focuses on a particular food category or process with the objectives of:

- Providing consumers with the most relevant and pertinent information available to enable them to make informed choices in respect to the food they eat.
- Helping consumers understand (a) how the food safety system works, (b) the efforts being taken by the regulators, producers, and industry, to reduce the inherent risks, and (c) the prudent sensible steps that can be taken to address both perceived and potential risks.
- Providing opportunities to promote good practice along the food chain.

The general terms of reference of each review are:

To report on foods in light of their impact on human health and consumer concerns, and in particular to:

1. Profile the food category, identify and describe the issues relevant to human health at various points along the food chain.
2. Report on how the food safety system works across the entire food chain.
3. Identify opportunities to communicate the human health benefits and potential risks of this food category to the consumer.
4. Examine the various communication needs of all stakeholders to influence the behaviour across the food chain.
5. Identify opportunities to highlight recommended best practices and develop communication programmes based on stakeholder needs.

The primary purpose of these reviews is directly pertaining to food safety and nutrition issues. However, other issues not directly related to food safety are discussed, for example training, labelling, etc.

Two reviews have been conducted to date. These have covered the Chicken and Finfish food chains.

1.3 Consumer Focused Review of Fruit and Vegetables

1.3.1 Introduction

Fruit and vegetables are key components of a healthy diet. They are low fat and low energy-dense foods, relatively rich in vitamins, minerals and other bioactive compounds, as well as being a good source of fibre.

A high intake of fruit and vegetables in the diet is positively associated with the prevention of cardiovascular disease; cancer; diabetes; and osteoporosis. There is also convincing evidence that a high dietary intake of fibre (most specifically non starch polysaccharide (NSP)) is a factor in protecting against weight gain and obesity as well as being an effective weight loss strategy. The World Health Organisation (WHO) advocates a daily intake of 400g of fruit and vegetables for health (this is equivalent to approximately five portions based on an average weight of 80g per portion).

In spite of the strong evidence in support of the health benefits and the reported awareness of these benefits, intakes of fruit and vegetables on the island of Ireland (IOI) are low.

From a food safety perspective, the risks associated with fresh fruit and vegetables are low. However, the proportion of foodborne illness associated with this category has increased over the last number of years. Along with promoting the increased consumption of fruit and vegetables, it is important that these risks are acknowledged and managed.

This review collates and considers the information available – academic, regulatory, public health – on the health and food safety implications of fruit and vegetables. On the basis of the evidence the review draws a number of conclusions, which may provide the basis for action for **safe food** and other agencies on the island, as well as for stakeholders, public health professionals and consumers.

1.3.2 Scope of the Review

This review of the fruit and vegetable food chain focuses only on ready-to-eat (RTE) fresh fruit and vegetables which are consumed raw, whether whole or prepared. Prepared refers to minimally processed fruits and vegetables. This means raw fresh cut produce, which have undergone minimal processing such as peeling, slicing or shredding. This includes products packaged under vacuum or in a modified atmosphere that have not undergone any treatment (chemical, physical or biological) to ensure preservation other than chilling.

The nutrition and health benefits chapters will, however, consider fruit and vegetables as a broad food group rather than looking at them as individual fruits or vegetables. This is because it is not known which components in this category are beneficial.

The review will not include potatoes, as they are classified into the ‘Breads, Cereals and Potatoes’ food group due to their high starch content and in general are not consumed raw. In some cases, however, market statistics will include potatoes (this will be clearly stated) as it would otherwise be impossible to segregate the data.

Fruit and vegetables are very similar with respect to their compositions, methods of cultivation and harvesting, storage properties and processing. In botanical terms, fruit is the portion of a plant which houses the seeds. Resultantly, a number of vegetables may be considered fruits. These include tomatoes, cucumbers, eggplant, and peppers. Another distinction between fruit and vegetables is based on usage. Plant items that are generally eaten with the main course of a meal are considered to be vegetables, while those commonly eaten as a dessert are considered fruits (Food Agricultural Organisation 1995). Throughout this document, the latter distinction between fruit and vegetables will apply, e.g. tomatoes are considered vegetables, unless otherwise stated.

1.3.3 Food Safety Risks in Fruit and Vegetables from a Consumer Perspective

1.3.3.1 Quantitative Research

safe food conducts bi-annual market research during which, amongst other things, it determines consumers' attitudes and behaviour to particular foods and food preparation habits. In its March 2006 research, consumers were asked regarding any food safety concerns that they may have with respect to fruit and vegetables. Consumers were also questioned on their awareness of the benefits of fruit and vegetable consumption.

The main unprompted concerns of consumers are outlined in Table 1.1.

Table 1.1 Issues of concern to consumers about the production, preparation and consumption of fruit and salad vegetables (Top five, unprompted)

Issue of concern	% concerned
Too many sprays/pesticides/insecticides	30
Washed properly	25
Freshness	15
Free from parasites	5
Packaging	4

Note: n = 831 (ROI – 519, NI – 312)

Presence of residues and freshness also featured highly in prompted consumer concerns (Table 1.2). In terms of assuring product safety at point of purchase, consumers identified no bruising or blemishes as the

Table 1.2 Prompted issues of concern to consumers about the production, preparation and consumption of fruit and salad vegetables

Issue of concern	% of respondents concerned
Presence of pesticide residues	68
Presence of parasites	66
Genetically modified crops	60
Presence of chlorine in prepackaged lettuce	57
Freshness of produce	56
Labelling	48
Packaging	47

Note: n = 831 (ROI – 519, NI – 312)

primary mechanism (Table 1.3).

Table 1.3 Indicators of quality and safety of produce

	% of respondents
No bruising or blemishes	70
Country of origin	51
Labelled as organic	50
Packaging	43
Place of purchase	29

Note: n = 831 (ROI – 519, NI – 312)

Just under half of consumers consulted were aware of the Five-a-Day message (Table 1.4); however, portion size was an area of confusion (Table 1.5).

Table 1.4 No. of portions of fruit and vegetables consumers think a person should eat daily

No. of daily portions	% of respondents
1	1
2	3
3	10
4	16
5	44
6	6
7	1
8	1
10	1
Don't know	17

Note: n = 831 (ROI – 519, NI – 312), highlighted sections indicate the correct answers.

Table 1.5 Consumer perception of portion size

	= less than one portion	= one portion	= more than one portion	Don't know
1 satsuma orange	23%	58%	5%	4%
A handful of dried fruit, e.g. raisins	23%	55%	6%	16%
1 red pepper	16%	54%	11%	20%
2 glasses of freshly squeezed orange juice	7%	48%	35%	10%
2 tablespoons of mushrooms	27%	48%	6%	19%
Half a melon	9%	57%	23%	12%
4 cherry tomatoes	18%	56%	12%	14%
A dessert bowl of mixed salad	7%	58%	22%	13%
1 apple	7%	82%	4%	8%

Note: n = 831 (ROI – 519, NI – 312), highlighted sections indicate the correct answers.

Examples of portion sizes of fruit and vegetables can be found in Appendix A.

1.3.3.2 Qualitative Research

In April 2006 **safefood** commissioned qualitative research to elicit consumers' perceptions of the fruit and vegetable supply chain driven by the above quantitative research, and also specifically relating to:

- behaviour, motivations and barriers towards purchase/consumption;
- storage, preparation, cooking and consumption; and
- associated contamination and microbiological risk.

Six discussion groups (eight participants per group) were held amongst fruit and vegetable consumers in the Republic of Ireland (ROI) and Northern Ireland (NI). The groups were conducted across urban (Dublin, Mullingar and Belfast) and rural (Newry and Wexford) locations to provide a mix and allow for regional variation, if applicable. Variation in target markets was taken into account when choosing the optimum group matrix, with emphasis placed on mothers who, in the main, were considered to take the responsibility in the family for the main grocery shop.

General Observations

Lifestyle impacted heavily on consumers' attitudes and perceptions towards the fruit and vegetable category. Mothers were very conscious of the nutrition and potential health benefits that fruit and vegetables have to offer their children. Many noted how schools were constantly advocating and promoting increased consumption. Most claimed that they do not consume enough fruit and vegetables themselves, and that habit and convenience played a part in reduced consumption.

Parents with older children (12 to 18 years) showed less concern for their children's fruit and vegetable consumption, as many felt that their children's diets were beyond parental control at this life stage. For young adults with no children, fruit and vegetables were an exotic and/or tasty component of a dish to be enjoyed, with health and dietary benefits being a primary driver of consumption. Shelf-life, however, was seen as an issue. Packaging in store was also criticised, where bulk buying offered value but was not suitable for all consumers. Men claimed to eat less fruit and vegetables than women due to habit, assumed inconvenience (in terms of preparation and cooking) and apathy.

Fruit and vegetables were cited as a routine element of the shopping trip and people's diet. All consumers noted how they needed to eat more and related the different ways that they tried to ensure that their families were following the Five-a-Day guideline. Methods used to encourage additional fruit and vegetable consumption included sauces, smoothies, juices and soup. Fresh was regarded as the best way to eat such produce, although some consumers expressed dissatisfaction about the inconvenience and hassle of preparation. The pros and cons of each type (fresh, processed, frozen and bagged) were identified (Table 1.6)

Table 1.6 Advantages and disadvantages for different forms of fruit and vegetables

	Advantages	Disadvantages
Fresh	Most natural, original state, least "tampered" with Best for you nutritionally	Hassle to prepare, work involved – washing, chopping, cleaning Expensive Not always ripe/tasty
Processed	Easy Convenient Cheap Bulk buy Store in cupboard	May not taste as good as fresh Contains preservatives/additives "Not as 'nutritionally' good for you" Added sugar and salt
Frozen	Simple No wastage Popular, e.g. peas, corn Convenient	"What has been done to it? Yet some claim, better for you than fresh" Loss of taste Funny formats Looks unappealing
Bagged	Easy, no hassle, straight forward	Expensive "Doesn't last", "goes off" Tastes different (not as good) "Bagged lettuce can be bad for you"

A number of benefits and barriers were identified in relation to consumption of fruit and vegetables (Table 1.7). Overall, however, the benefits were seen to outweigh any perceived risks due to good news stories and active promotion of the category.

Table 1.7 Triggers and Barriers behind Fruit and Vegetable Consumption

Triggers/Drivers

Healthy
Good for you
Low fat
Provide variety/range
Some are convenient/quick/fast/eat on the go, e.g. apple/tomato/peppers
Dieters are easily accommodated
Feel good factor
Tasty

Barriers/Disadvantages

Some inconvenient to prepare, e.g. lettuce, potatoes, cabbage, spinach
Expensive for volume/value purchasers
Lack of longevity/go off fast
Can be poor quality/not ripe, hit and miss
Can taste bland
What about pesticides, chemical sprays and genetic modification

Source of Fruit and Vegetables

The source of fruit and vegetables appeared to be more of an issue for those from rural backgrounds. There was an assumption that retailers would 'usually' source 'local producers' who engender trust and confidence, and were perceived to use more natural and/or traditional farming methods.

For those from more urban backgrounds, there was an assumption that 'local' was not as feasible and many expressed the hope that retailers were using the best supplier available to them.

Seasonality was perceived to have become less of an issue, as consumers have become used to having an assortment of fruit and vegetables all year round. Many noted how certain fruit had always been 'outsourced', e.g. citrus fruits, and this was seen to be more prevalent due to consumer demand for fruits all year round, e.g. strawberries.

Air miles (also referred to as 'food miles') were seen to be an issue and media attention on this issue at the time was noted. For many it was seen to be an inevitable, unfortunate side effect of outsourcing and some queried how good/safe it was for fruit and vegetables to be stored for extended periods of time along the supply chain.

Few, however, admitted to having actively sought out origin information at purchase point. 'Fairtrade' was mentioned as becoming more relevant but was seen to be driven by retailers and availability.

Organic

Division occurred across the groups regarding organic fruit and vegetables. In general, it was seen as a lifestyle choice. A summary of the perceptions of organic produce is provided in Table 1.8.

Table 1.8 Perceptions of organic produce

Positive

Assume its safer/less risky
Less: pesticides, preservatives, additives, fertilisers
Tastes better
Looks genuine
Smells real
More natural state
Not tampered with

Negative

Expensive – prohibitive cost for family/volume purchasers on a budget
Is it really better for you? (few thought that it was nutritionally better for you)
Less stringent/rigid farming practices may be in operation
Could be unsafe?
Middle class/yuppie concept

Food Safety Concerns

Food safety in the home was not perceived as being an issue, as consumers claimed that they were careful in their storage, preparation and cleaning practices. Consumers only associated fruit and vegetables with positive messages and only when deeply probed were they able to cite some concerns that they may have had in relation to the category.

The fruit and vegetable category was perceived as being one of the healthiest and also the safest food categories. The main concerns consumers had centered on the farming/production processes used, but heavy probing was required to get consumers to think of this. These included pesticides; chemical sprays; fertilisers; growth hormones/sprays; genetic modification; and unsafe farming practices. The main risks associated with these were the long term effects/illnesses they may cause in the future. For example, consumers feared the unknown and also a link to cancer and illness.

Mothers saw choking as a real concern for children and their fruit and vegetable consumption (pip, stones, and skin/peel). Many noted how they lacked real knowledge in the area of food safety regulation and assumed that their retailers were safeguarding their interests. In general, it was presumed that there were safeguards and standards in place which must be followed to protect consumers.

Most claimed that if fruit and vegetables were properly washed, then there was little risk. Many noted how easily freshness of fruit and vegetables could be detected (look/smell/texture/colour/best before date on packaging) and deduced that one would be unlikely to eat it if it was gone off, thus getting sick would not be an issue. Even on prompting, consumers were not aware of the risks of *Salmonella*/*E.coli*/parasites/Hepatitis A or contamination when it came to the fruit and vegetables category. They linked these dangers instead with poultry and meat products. A small minority had heard about the following in the media, but were unclear of the actual details or real risks posed: lettuce (*Listeria*/chlorine), parsnips (bleaching), mushrooms (cannot eat them raw) and strawberries (food poisoning).

Consumers were sceptical of scare stories and/or information about food (especially diets) in the media. They stated that they only believed them if they were communicated by a food safety authority, government department or spokesperson. The overall perception was that eating all things in moderation reduces any risk.

2. The Supply Chain

2.1 Introduction

The horticultural industry on IOI is small in a European context. Nonetheless it is an important indigenous industry contributing to the economy in terms of adding value to the domestic output and employment provision.

There is widespread domestic production of certain fruit and vegetables on the island, for example mushrooms and strawberries. However, the climate limits the production of a range of fruit and vegetables, which are grown in more temperate climates, such as bananas and citrus fruits (see Appendix B). Thus allied with seasonality, importation from other EU Member States (MS) and Third Countries is, and has always been, necessary to supply the demand for fruit and vegetables. Improved growing, storage and distribution, however, have enabled producers to reduce the negative influence of the seasons.

In order to explain the supply chain on IOI, it is first necessary to put it into context within the global and European fruit and vegetable supply chains.

2.2 The Global Supply Chain

Global fruit and vegetable production increased 47 percent from 813.7 million tonnes in 1990 to 1.2 billion tonnes in 2002. Population increased 18 percent and as a result per capita supply or availability increased from 155 to 193 kg over this period. Vegetable production represents 62 percent of total fruit and vegetable production. China is the leading global producer of fruit and vegetables (Cook 2003).

World imports of fruit and vegetables reached US\$76 (£40.89/€59.38) billion in 2001. The EU dominates the import market for fruit and vegetables, importing 48 percent of fruit and vegetables in 2001. Germany is the largest import market within the EU accounting for 12 percent of world imports. As a single country, the US is the largest import market for fruit and vegetable with an import share of 14 percent (Cook 2003).

The EU dominates world export trade as a group, with US\$28.2 (£15.17/€22.03)¹ billion in exports in 2001, representing a 40 percent share of the export market. The primary European exporters are Spain (10 percent), The Netherlands (primarily re-exports) (seven percent), Italy (six percent) and France (five percent). China and Mexico account for approximately six per cent of global exports. Countries well-known for their fruit exports, such as Chile, Brazil, Argentina and Ecuador have market shares of 2.3 percent or less and Australia and New Zealand have a one percent share (Cook 2003).

2.3 The European Context

Total EU consumption of fresh fruit was 25 million tonnes in 2003, while vegetable consumption (including potatoes) was 30 million tonnes. Italy, Germany and France dominate the market for fresh fruit and vegetables, together accounting for approximately half of total consumption. The market for fresh fruit and vegetables is saturated, however, and consumption levels are now stagnant (Profound 2004).

2.3.1 Production

In 2003, production of fresh fruit amounted to 56.5 million tonnes, while production of fresh vegetables amounted to 55.3 million tonnes (Profound 2004). The main types of fruit produced are grapes, apples and oranges. The main types of vegetables produced are tomatoes, lettuce and cabbages, onions, melons and carrots. Italy and Spain are the leading producers of both fruit and vegetables (Profound 2004). See Table 2.1 for further information.

¹Currency conversion rates: 1US\$ = 0.538068£ = 0.781311€, calculated 8 June 2006 online using <http://www.x-rates.com/calculator.html>.

Table 2.1 EU production of fruit and vegetables

Fresh Fruit		Fresh Vegetables	
Production	Million tonnes	Production	Million tonnes
Total	56.5	Total	55.3
Italy	16.6	Italy	15.5
Spain	16.5	Spain	11.9
Main Types		Main Types	
Grapes	25.1	Tomatoes	15.4
Apples	8.8	Lettuce and Cabbages	6.0
Oranges	6.6	Onions	4.0
Melons	4.0	Carrots	3.8

Source: (Bord Bia 2006)

2.3.2 Imports

In 2002, total EU imports (both intra-EU and those from Third Countries) of fresh fruit amounted to 18.9 million tonnes (€14.8/£10.2² billion). Imports from Third Countries to MS amounted to eight million tonnes (€6.1/£4.2² billion). Germany, the UK and France are the leading importers of fresh fruit, while the leading suppliers are Spain, Italy, The Netherlands, France and Belgium. Bananas are the most popular imported fruit to the EU, accounting for 65 percent of fruit imports. Other popular imported fruit include apples, grapes and several citrus fruits (Profound 2004). The largest Third Country suppliers to the EU market are South Africa, Costa Rica, and several South American Countries (United States Department of Agriculture 2004). See Appendix C for further information on the leading suppliers of fruit and vegetables to the EU.

Imports of fresh vegetables to the EU (both intra-EU and from Third Countries) amounted to almost nine million tonnes (€8.4/£5.8² billion) in 2002. The leading importers are Germany, the UK, France and The Netherlands. Spain is the leading supplier of all EU (both intra and extra) imports, accounting for nearly one quarter of total supplies in terms of value in 2002. Tomatoes, capsicum, lettuce and onions are the main imported fresh vegetables. Whereas Latin-American countries dominate Third Country imports of fruit, African countries are important Third Country suppliers of vegetables. Nevertheless, vegetable imports are dominated by intra-EU trade, notably more than fruit imports (Profound 2004).

2.3.3 Exports

In 2002, total exports of fresh fruit amounted to almost 13.9 million tonnes (€10.3/£7.1² billion) which mainly concerned intra-EU trade. The leading exporting countries are Spain and Italy. The leading fresh fruit products exported are apples, oranges, bananas (mainly re-exports) and mandarins/clementines (Profound 2004).

Exports of fresh vegetables amounted to 9.2 million tonnes (€8.0/£5.5² billion) in 2002. Spain and The Netherlands are the leading exporters, together accounting for two thirds of total EU exports (in value) in 2002. Contrary to the Spanish exports, which consist mainly of domestic produce, the majority of the Netherlands exports consist of re-exports. The fresh vegetables exported are mainly traded within the EU itself. Only about 14 percent is exported to countries outside the EU. The main fresh vegetables exported are tomatoes, capsicum and lettuce (Profound 2004).

²Currency conversion rates: 1€= 0.688673£, calculated 8 June 2006 online using <http://www.x-rates.com/calculator.html>.

2.4 Island of Ireland

2.4.1 Introduction

The horticultural food sector on ROI has a farm gate value in excess of €350 (£217.25) million. The fruit and vegetable category on ROI can be subdivided into fruit, field vegetables, protected crops and mushrooms (Bord Bia 2005a).

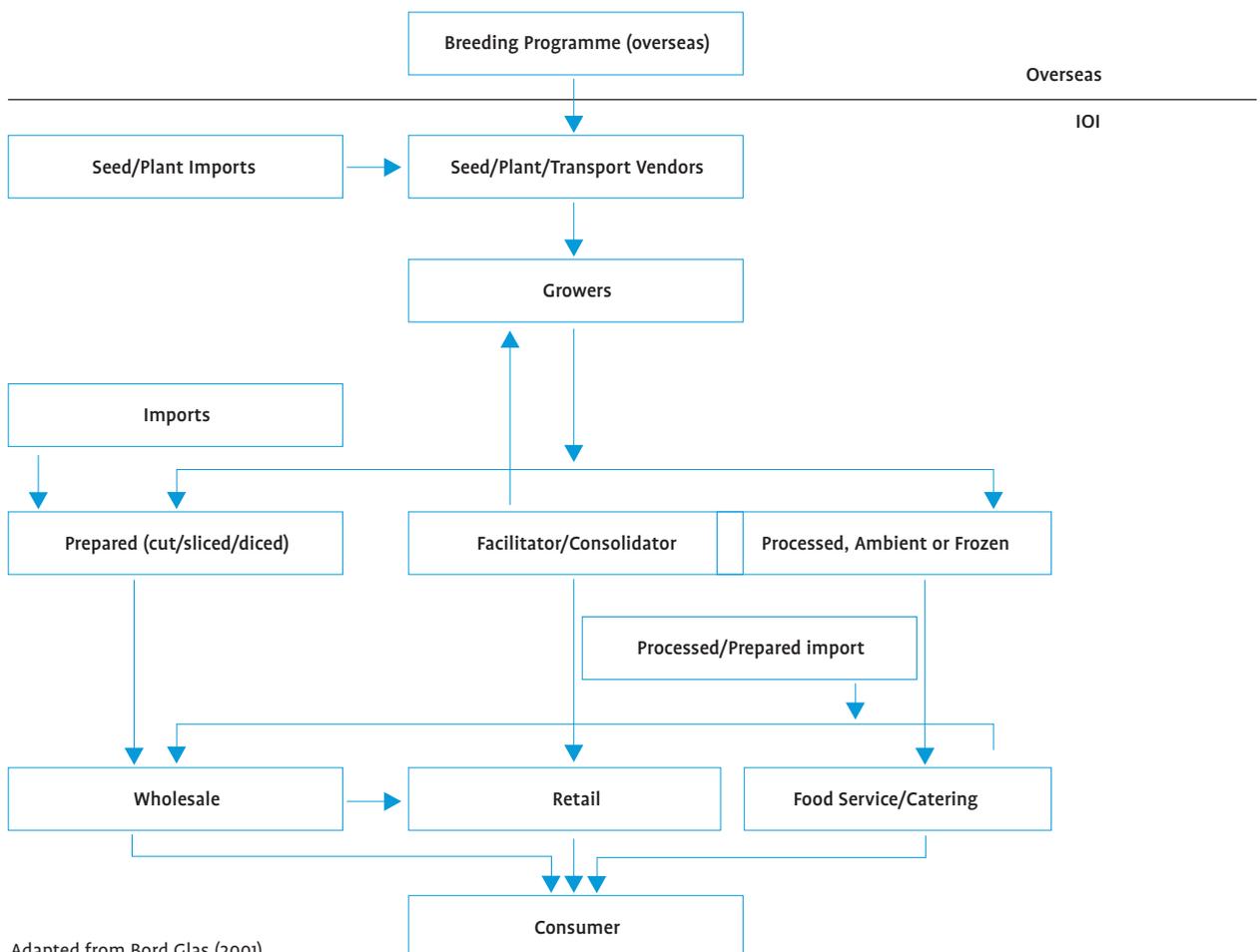
There are approximately 1,400 horticultural food growers involved in a range of farm enterprises including mushrooms, potatoes, field vegetables, protected crops and outdoor fruit and honey. The outdoor element of the horticultural food industry comprises 18,850 hectares of field grown crops (including potatoes, field vegetables and soft fruit) and 631 hectares of orchards (Bord Bia 2005a).

Horticultural food sales on NI have a farm gate value of £69.4 (€111.7⁴) million. Horticulture land usage is 9,700 hectares in NI (Department of Agriculture and Rural Development 2006).

The horticultural industry is labour intensive (especially in planting and harvesting operations) when compared with other agricultural sectors. While production of fruit and vegetables has significantly mechanised in recent years, there still are a number of crops that have to be hand harvested (majority of soft fruits). There are 4,500 Full Time Equivalent (FTEs) employed in the food horticulture sector in ROI, of which 1,032 are employed in field vegetables, 897 in protected crops and 175 in fruit (Bord Bia 2005b). There are 1,630 FTEs employed in the fruit and vegetable sector³ in NI. (DARD 2006)

The fruit and vegetable supply chain on IOI is outlined in Figure 2.1.

Figure 2.1 Fruit and vegetable supply chain on IOI



³ Fruit and Vegetables – Covers a wide range of businesses from those principally involved in the grading and packing of fruit and vegetables to those which manufacture products such as potato crisps. All of the businesses within this sub sector used fruit and vegetables grown in NI. Wholesale fruit and vegetable businesses are excluded.

A range of factors (including climate and soil type) influence the location of growers. However, over the past five to ten years, the major supermarket multiples have moved to a system of centralised distribution which has led to a clustering of producers within range of the major centralised distribution centres, most of which are close to the large urban areas centered on Dublin, Belfast and Cork (Table 2.2).

Table 2.2 Horticulture clusters on IOI

Sector	Locations
Mushrooms	Monaghan / Cavan / Armagh
Apples	Armagh / Louth / Monaghan Tipperary / Waterford / Kilkenny
Field Vegetables	Dublin / Meath Down/Armagh/Londonderry Cork Wexford
Fruit (excluding apples)	Wexford Cork Dublin / Meath / Louth
Protected Crops	Dublin / Meath / Louth Cork Wexford

Adapted from: Intertrade Ireland (2004)

Although there are a large number of fruit and vegetable growers in ROI, industry sources estimate that in 2004 there were only about 250 commercial growers (Forfás 2004).

2.4.2 Production

The farm gate value of fruit and vegetables on IOI was approximately £186/€300 million and there were approximately 1733 producers on the island in 2004 (Table 2.3).

Table 2.3 Farm gate production value of fruit and vegetables on IOI, 2002

Output	NI	ROI	No. of Producers	NI	ROI	No. of Producers
	Stg £ (millions)	€ (millions)		Stg £ (millions)	€ (millions)	
Fruit	3.0	4.8	331	5.5	8.8	218
Field Vegetables	14.9	23.9	176*	27.4	44.2	294
Protected Crops	See field vegetables			22.3	36.0	153
Mushrooms	27.6	44.4	226	85.5	137.7	335
Total	45.5	73.1	733	140.7	226.7	1000

Source: Intertrade Ireland (2004)

* includes protected crops

2.4.2.1 Protected Crops

The main food crops grown under protective covers in ROI include tomatoes, followed by lettuce, cucumbers, celery, peppers and strawberries. In value terms, tomatoes and lettuce are the most important crops in this sector and account for two thirds of the total protected crop output. Cucumbers and celery are the other key contributors to this sector (Bord Bia 2005c).

Increasing costs of production and lower prices have led to a reduction in the number of growers in the sector. In 2002 the sector was worth €36/£24.8² million at farm gate and there were 153 growers with a total growing area of 236 hectares. In 2004 the value was €18/£12.4² million (at farm gate), with 95 producers growing on 192 hectares (Bord Bia 2005d).

Comparative data for NI are not available separately to overall UK figures.

2.4.2.2 Field Vegetables

The field vegetable sector is the third most important horticultural food sector in ROI, valued at €57/£39.3² million (at farm gate) in 2004. Cabbage and carrots are the two most important crops, both in terms of production and value, worth €7/£4.8² million and €1/£7.6² million, respectively (Bord Bia 2005e).

There are 294 growers of field vegetables, with 50 growers accounting for 60 percent of total production output. In terms of field crops grown, brassicas account for half of all field vegetable production area in ROI, whilst root crops account for 35 percent of the total production area. Other significant field vegetable crops include alliums (e.g. onions and leeks), outdoor lettuce, celery and peas (for processing).

Comparative data for NI are not available separately to overall UK figures.

2.4.2.3 Soft Fruits

In ROI, the soft fruit sector produces nearly 80 percent (€19.2/£13.2² million) of its output value as indoor strawberries (Bord Bia 2005d).

Comparative data for NI are not available separately to overall UK figures.

2.4.2.4 Mushrooms

The mushroom sector on IOI has been experiencing a sharp decline in grower numbers in recent years. In ROI for example, numbers have fallen from 504 in 2000, to 242 in 2004. Output (in terms of quantity) in this period, however, remained relatively unchanged from the 65,000 tonnes recorded in 2001. The growers remaining in the sector are increasing their scale of operation and investing in their businesses. The value of the output on ROI was €115/£79.2² million in 2004 compared to €128 (£88.2²) million in 2001 (Department of Agriculture and Food 2004).

The industry is coming under pressure from a number of sources, including production costs, levelling off of market growth and competition within the U.K. retail sector from the Dutch and Polish mushroom industry (over 80 percent of ROI mushroom production is exported to the UK). The industry in ROI employed 3,000 people in 2004 (Department of Agriculture and Food 2004).

Comparative data for NI are not available separately to overall UK figures. However, there are currently 171 mushroom growers in NI.

2.4.3 Imports

The climate on IOI naturally restricts the growing of certain fruits and as such is heavily dependent on imports (e.g. citrus fruits, bananas, grapes, etc).

The fruit crops grown on IOI are seasonal and hence importation is necessary at certain times of the year to maintain continuity of supply (e.g. strawberries, apples).

ROI is approximately 80 percent sufficient in its domestic fruit and vegetable production (Forfás 2004). Imports were valued at €344 (£236.9²) million in 2003, a decrease of three percent on 2002 (Forfás 2004). Figures for NI are not available separately to overall UK figures.

2.4.4 Exports

Fruit and vegetable production on IOI is largely focused on producing for the domestic market, with a minimal amount being exported. Exports from NI were valued at £89.8 (€130.4⁴) million in 2003. The majority of sales (42 percent) were on the home market, with 39 percent in GB, and 19 percent in ROI (DARD 2006). The only major exports from ROI are mushrooms which are estimated at €75m (sold principally into the UK market) (Bord Bia 2005a).

2.4.5 The Organic Market

There is very limited production of organic fruit and vegetables in NI. There are approximately 19 producers, utilizing an area of 28 hectares. Within this, there is one producer growing on four hectares that supplies leeks and cabbages to a supermarket chain. The remaining producers are market gardeners with crop areas ranging from less than one to up to three hectares (Saunders 2006).

Of the 923 registered organic producers in ROI in 2003, there are 77 producers growing organic vegetables, and 22 growing organic fruit. The most important counties for vegetables are Cork (16 percent of all vegetable producers), Galway (12 percent), Wicklow (9 percent) and Clare (9 percent) (Department of Agriculture and Food 2003).

2.4.6 Retail

The value of the NI retail market for fresh horticulture produce was estimated at £234.9 (€375.8⁴) million in 2001 (Intertrade Ireland 2004). In 2005, the horticultural food market in ROI was valued at €996.8 million (£686.5⁴), at retail selling price. Fresh vegetables accounted for 38 percent of this market, while fruit accounted for 46 percent. Prepackaged fruit and vegetables account for 71 percent of retail sales, with the remainder sold loose (Bord Bia 2006).

The multiple supermarkets dominate the distribution of fresh vegetables on IOI (Intertrade Ireland 2004). In ROI three quarters of fruit and vegetable produce goes through the multiples (Forfás, 2004).

In ROI tomatoes accounted for the highest consumer spend on vegetables followed by carrots and mushrooms (Table 2.4) (Bord Bia 2006).

Table 2.4 Retail value of vegetables 2005 (ROI)²

Vegetables	€million	£ million ²
Tomatoes	74.7	51.4
Carrots	49.1	33.8
Mushroom	35.7	24.6
Peppers	33.3	22.9
Onions	26.4	18.1
Broccoli	22.0	15.2
Lettuce	21.3	14.7
Cabbage	13.9	9.6
Parsnips	11.9	8.2
Swedes/Turnips	11.9	8.2

Source: Bord Bia (2006)

Fruit sales are dominated by apples, citrus fruits and bananas (Table 2.5).

⁴Currency conversion rates: 1£ = 1.45206€ calculated 8 June 2006 online using <http://www.x-rates.com/calculator.html>.

Table 2.5 Retail value of fruit 2005 (ROI)²

Fruit	€million	£ million ²	Market share (%)
Total Apples	117.3	80.78	25.9
Dessert Apples	108.6	74.5	24.0
Total Citrus			18.4
Banana			16.2
Grapes			12.0
Total Berries			9.0
Strawberries	32.4	22.3	7.1
Total Tropical Fruits			7.5
Pears	26.7	18.4	5.9
Total Soft Fruits			5.0

Source: Bord Bia (2006)

Table 2.6 Prepared chilled produce market share 2005

	Volume Share (%)	Value Share (%)
Vegetables	23.4	18.8
Fruit	2.8	3.5
Leafy Salad	27.0	40.3
Mixed Tray/ Bowl Salads	2.7	2.8
Wet Salads	44.1	34.6

Source: Bord Bia (2006)

In terms of prepared chilled produce in ROI, sales of leafy salads and mixed tray/bowl salads are growing year on year (Table 2.6).

2.4.6.1 Organic

It has been estimated that organic vegetable retail sales in NI are worth £1.3 (€2.5)⁴ million. As already mentioned, there is only one grower in NI supplying vegetables to the local market, thus the majority of this figure is represented by external suppliers (Saunders 2006).

The current retail market value for vegetables in ROI is approximately €8.89 (£6.12)² million and the fruit market is valued at a further €1.27 (£0.87)² million. Combined, this translates to between two percent and three percent market penetration of the domestic fruit and vegetable retail market. The industry estimates that the market is growing at a rate of 30 percent per annum. In ROI the largest share of all organic sales, 43 percent, is for fruit and vegetables. Currently, however, producers are not meeting the volume requirements of wholesalers and retailers and as a result approximately 70 percent of organic produce sold in retail outlets is imported (Teagasc 2001).

2.4.7 Food Service

Despite the size of the food service sector, there is limited information on the value of fruit and vegetables purchases in both NI and ROI by this sector. It is estimated that the food service sector in NI spends £320 (€515)⁴ million on fruit and vegetable produce per annum (Intertrade Ireland 2004), while in ROI, €1.1 (£0.76)² billion is spent on the procurement of fruit, vegetables and potatoes (Bord Bia 2005f).

2.4.8 Processing

It is estimated that turnover in the fruit and vegetable processing sector in 2000 in ROI was €269 (£164)² million, while in NI it was £123.3 (€202.2)⁴ million (Intertrade Ireland 2004).

The growth in the processing sector on ROI and NI stems from the increased demand for pizza toppings, salads and prepared foods. Of the 45 businesses involved in fruit and vegetable processing in NI in 2000, the vast majority (93 percent) had turnover less than £10 (€15.7)⁴ million, with full time employment recorded at 1,365. The manufacturing and processing industries in ROI typically look to international suppliers to supply their needs for frozen ingredients at commodity prices (Intertrade Ireland 2004).

Specific data relating to the extent of on-farm processing of fruit and/or vegetables on the island and the nature of processed vegetables for sale to consumers through catering or retail establishments is currently unavailable.

3. Food Safety

3.1 Introduction

Fresh fruit and vegetables are key components of a healthy diet. The risk of associated infectious disease is low and mechanisms by which contamination occurs are preventable. Good hygiene and agricultural practices from farm to fork can limit contamination and microbial growth in these products. The public health challenge is clear – to promote and increase the consumption of fruit and vegetables while also promoting and enforcing strict hygiene measures and agricultural practices that ensure safe, fresh produce for the consumer.

This chapter looks at the microbiological and toxicological aspects of the fruit and vegetable supply chain. This includes the hazards and risks associated with fresh fruit and vegetables, and the controls in place to minimise any associated risk. The controls on produce imported from Third Countries are also discussed at the end of this chapter.

3.2 Microbiology

3.2.1 Introduction

Microorganisms form part of the epiphytic flora of fruits and vegetables. This means that they grow on plants but are not parasitic to them, and thus many will be present at the time of consumption. The numbers of bacteria present will vary depending on seasonal and climatic variation with populations of 10^5 to 10^7 CFU (colony forming units) g^{-1} being frequently present (Francis, Thomas et al. 1999). The majority of bacteria found on the surface of plants are usually Gram negative and belong to the *Pseudomonas* group or to the family *Enterobacteriaceae*. Many of these organisms are normally non-pathogenic for humans with intact immune systems (Lund 1992).

There are many points during production of fruits and vegetables at which microbiological contamination can occur. These include:

- Growing (seeds, soil, water, manure, insects, animals)
- Harvesting (faeces, handling, equipment, transport)
- Post-harvest handling (washing, packing, vehicles, cross-contamination) (Everis 2004).

From a human health perspective, contamination of pathogens from human or animal sources is likely to present the greatest risk.

The natural structures covering the outside of fruit and vegetables provide excellent protection against the entry and subsequent damage by spoilage organisms (Jay 1986). The inner tissues of fruit and vegetables are usually regarded as sterile (Lund 1992) but the application of processing technologies such as cutting, slicing, skinning and shredding will disrupt the natural protective barriers of the intact plant and open the possibility for a suitable medium for the growth of contaminating microorganisms (European Commission Scientific Committee on Food 2002). Internalisation of microorganisms may also be facilitated by root or stomata uptake and also by damage sustained in the field, or during harvesting and post-harvest stages. The range of microorganisms capable of growing on such products and their growth rates will be determined by the intrinsic parameters and the storage conditions.

Intrinsic factors are those parameters that are inherent characteristics of plant tissues. These include the natural pH value; moisture content; oxidation-reduction (Eh) potential; nutrient content; antimicrobial constituents; and biological structures.

In general, the high water content of fruit and vegetables, the favourable Eh value and ready supply of nutrients make such products suitable substrates for microbial growth. The low pH value of fruits, however, favours the growth of yeasts and moulds that are more acid tolerant than bacteria; while the low B vitamin content of fruits favour the growth of Gram negative bacteria and moulds (Jay 1986).

The presence of natural antimicrobial constituents in some fruit and vegetables has been reported. The hydroxycinnamic acid derivatives (*p*-coumaric, ferulic, caffeic, and chlorogenic acids) found in fruit, vegetables, tea, molasses and other plant sources all show antibacterial and some antifungal activity (Jay 1986). Moreover, cranberries are a natural source of benzoic acid which is an antimicrobial.

3.2.2 Foodborne Human Infections Associated with Fresh Produce

Fruit and vegetables (also termed 'fresh produce') are increasingly being recognised as an emerging vehicle for foodborne illness in humans. Traditionally meat, milk and egg products were the 'usual suspects'. The consumption of fresh produce has now been linked, both epidemiologically and microbiologically to infectious intestinal disease. However, illness as a result of consumption of this category represents only a small proportion of the total number of reported cases. For example, only 1.4 to three percent of outbreaks were associated with fruit and vegetables in the US between 1993 and 1997 (European Commission Scientific Committee on Food 2002). Nevertheless, outbreaks associated with uncooked produce in the US are increasing in absolute numbers and as a proportion of all reported foodborne outbreaks. There has been a doubling of fruit- and vegetable-associated outbreaks between the periods 1973 to 1987 and 1988 to 1992 (Olsen, MacKinon et al. 2000).

3.2.2.1 Epidemiological and Microbiological Information Limitations

Tracing individual episodes of human infection to a particular food is inherently difficult. Estimating the risks associated with consuming different foods is a complex epidemiological process. Disease risks from foods can only be derived from the analysis and interpretation of a large body of evidence. This evidence includes laboratory infectious disease surveillance data; hospital episode statistics; food intake surveys; outbreak surveillance data; death statistics; and special studies related to infectious disease outbreak investigations. It should be noted that caution must be exercised in attributing infections to specific foods.

There is, however, a body of evidence to link the consumption of fresh produce to infectious disease in humans. Nevertheless, the low incidence of international food poisoning outbreaks due to fresh produce is fairly consistent throughout different surveys (Everis 2004).

There are some important features associated with the role of fresh produce acting as vehicles of intestinal infection. Contamination often occurs early in the production process, e.g. via animal manure or contaminated water used during growth or harvesting. Ingredients from many countries may be combined in a single dish making the specific source of contamination difficult to trace. Fresh produce foods typically have fewer barriers to microbial growth such as preservatives; therefore, simple errors can make the food unsafe.

Definitively tracing back the produce source of an outbreak may be impossible because this food usually has a short shelf life and may have exited the food chain by the time the outbreak is recognised (De Roever 1999). Also, consumers may not remember eating produce in the form of garnishes, e.g. parsley (Holtby, Tebbutt et al. 2001).

The involvement of multiple countries or regions is a particular feature of outbreaks associated with fresh produce. This is recognised as an important and emerging public health concern. In recent years fresh produce categories such as raspberries, melon, lettuce, fruit juices and sprouted seeds have been implicated as vehicles in multi-country outbreaks of a range of intestinal infections including salmonellosis, shigellosis, hepatitis, and *E. coli* O157:H7.

The widespread geographic distribution of these minimally processed RTE foods results in outbreaks that are very difficult to detect. Only a few sporadic cases may be detected in any given jurisdiction. The identification of multi-country outbreaks is facilitated if the causative organism is of an unusual serotype and the epidemiologic and laboratory authorities collaborate at the relevant international level.

This phenomenon is well illustrated by simultaneous outbreaks of *Shigella sonnei* and Enterotoxigenic *E. coli* O157:H7 infections associated with parsley in the US and Canada in 1998 (Naimi, Wicklund et al. 2003). A 1,600 acre farm in Mexico was the likely source of the parsley sourced in the six of the seven *Shigella* outbreaks. The farm was also identified as a possible source in the two *E. coli* O157:H7 outbreaks.

3.2.2.2 Human Outbreaks Associated with Fresh Produce

Data from population-based studies and surveillance systems have been analysed to estimate the burden of disease associated with fresh produce consumption.

Outbreak Data from England and Wales

One hundred and thirty five (7.7 percent) of the outbreaks of infectious intestinal disease reported to the Communicable Disease Surveillance Centre (CDSC) in England and Wales during the years 1992 to 2003 were associated with the consumption of salad, vegetables or fruit (Advisory Committee on the Microbiological Safety of Food 2005). The pathogens most frequently reported in these outbreaks were *Salmonella* (21 percent), *Norovirus* (17 percent), *Shigella* (six percent), *Campylobacter* (five percent), *E. coli* O157 (three percent). No organism was identified in 33 percent of these outbreaks. A marked seasonal variation in these outbreaks was also evident with over half (56 percent) occurring during the summer months of May to August.

Most outbreaks were linked to catering premises (73 percent). Cross-contamination (38 percent) and infected food handlers (25 percent) were identified as the two major factors facilitating produce-related outbreaks. When this is compared to all foodborne outbreaks a different ranking of contributing factors emerges, with inappropriate storage (27 percent), inadequate heat treatment (27 percent) and cross-contamination (25 percent) featuring as the major factors.

Cross-contamination is understandably a major contributing factor in outbreaks involving fresh produce as these foods are usually eaten raw.

A major study (Adak, Meakins et al. 2005) conducted in England and Wales during the period 1996 to 2000 demonstrated that only three percent of cases of indigenous foodborne disease were attributed to fruit and vegetable consumption (Table 3.1).

Table 3.1 Estimated annual impact of indigenous foodborne disease, by selected food group and type, England and Wales

Food Group/Type	Cases	(%)	Death	(%)	Case-Fatality Rate*
Poultry	502,634	(29)	191	(28)	38
Chicken	398,420	(23)	141	(21)	35
Eggs	103,740	(6)	46	(7)	44
Red Meat	287,485	(17)	164	(24)	57
Seafood	116,603	(7)	30	(4)	26
Shellfish	77,019	(4)	16	(2)	21
Milk	108,043	(6)	37	(5)	34
Vegetable/Fruit	49,642	(3)	14	(2)	29
Salad Vegetables	37,496	(2)	11	(2)	28
Cooked Vegetables	6,870	(0)	2	(0)	35
Fruit	5,275	(0)	1	(0)	25

n = 1,724,315 *Deaths/100,000 cases Source: Adak, Meakins et al. (2005)

When severity of illness measures, such as hospitalisation and deaths, were taken into consideration, a low level of risk was associated with the consumption of fresh produce. Within this category salad vegetables constituted the majority of the risk (76 percent) with cooked vegetables (14 percent) and fruit (ten percent).

Nevertheless, the healthcare impact arising from fresh produce was low (Table 3.2).

Table 3.2 Estimated annual healthcare impact of indigenous foodborne disease, by selected food group and type, England and Wales

Food Group/Type	General Practitioner Cases (%)	Hospital cases (%)	Hospital Days (%)
Poultry	159,433 (35)	9,952 (45)	41,645 (41)
Chicken	129,271 (28)	9,005 (41)	36,425 (36)
Eggs	19,554 (4)	552 (3)	3,410 (3)
Red Meat	80,805 (18)	1,231 (6)	10,935 (11)
Seafood	23,998 (5)	828 (4)	3,690 (4)
Shellfish	12,861 (3)	134 (1)	752 (1)
Milk	40,755 (9)	3,681 (17)	14,176 (14)
Vegetable/Fruit	11,912 (3)	702 (3)	2,932 (3)
Salad Vegetables	9,874 (2)	660 (3)	2,671 (3)
Cooked Vegetables	1,184 (0)	27 (0)	168 (0)
Fruit	853 (0)	15 (0)	93 (0)

* Totals given are calculated on the basis of rounding to whole numbers. Source: Adak, Meakins et al. (2005)

Analysis by food group (Table 3.3) demonstrated that vegetables and fruit had the lowest disease and hospitalisation risks while chicken had the highest. Within this category, there is a distinction between the ‘extremely low risk’ posed by fruit and cooked vegetables and the ‘very low risk’ attributable to salad vegetables. The estimated risk of foodborne infection associated with the category vegetable/fruit was one case per million servings in England and Wales during the period reviewed.

Table 3.3 Estimated risks associated with food groups and type, England and Wales

Food Group/Type	Disease Risk*	Risk Ratio	Hospitalisation Risk†	Risk Ratio
Poultry	104	947	2,063	4,584
Chicken	111	1,013	2,518	5,595
Eggs	49	448	262	583
Red Meat	24	217	102	227
Seafood	41	374	293	650
Shellfish	646	5,869	1,121	2,490
Milk	4	35	133	295
Vegetable/Fruit	1	NA	8	NA
Salad Vegetables	6	53	103	229
Cooked Vegetables	0	1	0	1
Fruit	0	2	1	1

* Cases/1 million servings † Hospitalisations/1 billion servings NA: not applicable Source: Adak, Meakins et al. (2005)

Outbreak Data from the EU

A review conducted in Sweden (Lindqvist, Andersson et al. 2000) demonstrated that salads containing one or more cooked ingredients accounted for 4.3 percent of the reported incidents during that time. Higher figures have been reported in some countries (Schmidt 1995); however, the figures are not directly comparable as it is not always possible to separate categories such as salad dressings (perhaps containing raw egg) from data on fruit and vegetables.

The number of outbreaks reported in some jurisdictions is more likely to reflect the comprehensiveness of surveillance than the scale of true problems with fresh produce in that country.

A risk profile of raw vegetables and fruit conducted by the European Commission’s Scientific Committee on Food (SCF 2002) found that the majority of the attributed outbreaks were associated with intact products grown in contact with the soil or water. Fewer outbreaks have been associated with cut/sliced/skinned or shredded products, while a significant number have been linked to sprouted seeds and fruit juices. All of the outbreaks linked to sprouted seeds and fruit juices (with the exception of one fruit juice outbreak) have involved bacteria, in particular *Salmonella*.

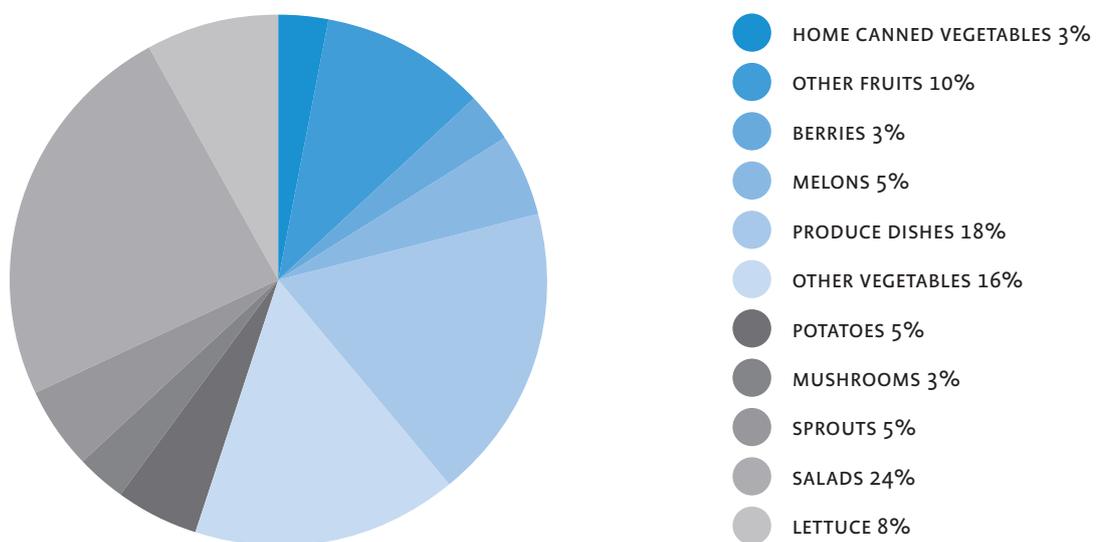
The frequency of produce associated outbreaks in Europe appears to be similar to the US (European Commission Scientific Committee on Food 2002).

Outbreak Data from the USA

In the US, the Centre for Science in the Public Interest (CSPI) maintains its own database of foodborne illness outbreaks, compiled largely from data from the Centre for Disease Control (CDC) in Atlanta, the State Health Department and peer-reviewed articles.

A total of 554 foodborne illness outbreaks involving 28,315 cases linked to fresh produce and fresh produce dishes were reported by the CSPI during the period 1990 to 2003 (CSPI 2005). The produce category had an average of 51 cases per outbreak; vegetables were linked to 205 outbreaks with 10,358 cases; while fruits were identified as the vehicle in 93 outbreaks with 7,799 cases. Of the 93 fruit associated outbreaks, 15 were linked to berries and 25 were linked to melon. Fresh produce dishes were implicated in 256 outbreaks involving 10,158 cases. In produce-linked outbreaks, *Salmonella* spp., Noroviruses, and *Cyclospora* spp. accounted for the majority of cases of foodborne illness. See Figure 3.1 for an overview of produce-related outbreaks in the US.

Figure 3.1 USA Vehicles of produce-related outbreaks, 1990 to 2003



Source: CSPI (2005)

Outbreak Data from IOI

Northern Ireland

Two outbreaks in NI have been associated with eating lettuce. An outbreak of *Salmonella* Newport in England, Scotland and NI occurred during the period of September to October 2004. Over 350 people in England, NI, Scotland and the Isle of Man, were affected, with 20 people being hospitalised. The NI cases comprised 113 of the 372 reported cases. Food histories implicated fast-food premises and a case-control study undertaken in NI, in agreement with one conducted in Lincolnshire, demonstrated an association with 'Iceberg' lettuce consumption in restaurants, fast food and take-away premises. It appeared that the lettuce had only been supplied to catering premises and not to retail traders. There were no confirmed cases of the illness in ROI, however, surveillance was increased as there was one case of *S. Newport* in Co. Donegal which may have been associated with the UK outbreak. Further investigation linked the outbreaks with adverse weather conditions in Spain where the lettuce had been grown that had resulted in run-off and contamination of the crop (Health Protection Agency 2004).

Prior to this, in May 1997, a *Campylobacter* outbreak was notified to CDSC NI and the suspect vehicle was seasonal leaves/tomatoes (Smyth 2006).

Republic of Ireland

No outbreaks associated with produce have been recorded on the current Health Protection Surveillance Centre outbreak surveillance system in ROI (McQuaid 2006). Salad was identified as a potential source of five linked cases of *Salmonella* Infantis in 1998. The evidence was based on epidemiological rather than microbiological data (McQuaid 2006).

3.2.2.3 Pathogens associated with RTE fruit and vegetables

A wide range of fruit and vegetables have been implicated in foodborne illness, as demonstrated in the previous section. With global distribution systems providing a continuous supply of seasonal produce, it is likely that the diverse locations from which fruit and vegetables are sourced will result in exposure to pathogens far removed from the point of contamination.

The pathogens most commonly associated with fruit and raw vegetables are grouped in Table 3.4.

Table 3.4 Pathogens transmitted via fruit and vegetables

Bacterial	<i>Aeromonas</i>
	<i>Bacillus cereus</i>
	<i>Campylobacter</i>
	<i>Clostridium botulinum</i>
	<i>Clostridium perfringens</i>
	<i>Escherichia coli</i> O157
	<i>Listeria monocytogenes</i>
	<i>Salmonella</i>
	<i>Shigella</i>
	<i>Staphylococcus aureus</i>
<i>Vibrio cholerae</i>	
Viral	Hepatitis A
	Norovirus
Protozoan	<i>Cryptosporidium parvum</i>
	<i>Cyclospora cayetansis</i>
	<i>Giardia</i>

Adapted from European Commission SCF (2002) and Everis (2004)

3.2.2.4 Pathogens Associated with Infectious Disease Outbreaks

(a) *Salmonella*

There have been a number of reports of international outbreaks of salmonellosis linked with the consumption of fresh fruit and vegetables. Both watermelons and cantaloupe melons have been associated with *Salmonella* infections. Examples include watermelons in 1979, and 1993; cantaloupes in 1990 and pre-sliced cantaloupes linked to *S. Poona* infections in 1991 (O'Brien, Mitchell et al. 2000). The rapid growth of *Salmonella* on cantaloupe, honeydew and watermelons has been reported, with the recorded pH values of the melons involved (5.9 to 6.7) not exerting any antimicrobial effect (Everis 2004).

Salmonella has also been shown to survive in a variety of products including more acidic fruits such as apples and tomatoes during refrigerated storage for prolonged periods, with growth being observed at ambient temperatures. In two outbreaks of *S. Javiana* and *S. Montevideo* associated with the consumption of fresh tomatoes in the early 1990s in the US, water baths used by tomato packers were the most likely sources of contamination (Wood, Hedburg et al. 1991; Centers for Disease Control (CDC) 1993).

The survival of *Salmonella* for 12 days on shredded lettuce has been reported and growth on minimally processed cabbage recorded during storage at mild temperature abuse conditions (Everis 2004). As mentioned previously in relation to outbreaks on IOI, over 350 people in England, NI, Scotland and the Isle of Man, were affected by the relatively rare strain of *S. Newport* in 2004 as a result of the consumption of contaminated 'Iceberg' lettuce.

Bean sprouts have also been implicated in outbreaks of *S. Saint-Paul* in the UK and Sweden (Taormina, Beuchat et al. 1999). During the 1990s, outbreaks of a range of *Salmonella* serotypes (Stanley, Newport, Infantis and Anatum) in the US, Finland and Canada were associated with contaminated alfalfa sprouts (Taormina, Beuchat et al. 1999).

(b) *Shigella*

The primary spread of *Shigella sonnei* is by the person-to-person route, although food and waterborne transmission are reported. Outbreaks of shigellosis have been attributed to the consumption of raw vegetables (O'Brien, Mitchell et al. 2000). In 1994 a number of cases of *S. sonnei* occurred in European countries (Norway, Sweden and the UK). These were linked to 'Iceberg' lettuce from Spain (Frost, McEvoy et al. 1995; Kapperud, Rorvik et al. 1995).

In 1994 an outbreak in the US was epidemiologically linked to contaminated scallions of Mexican and US origin (Cook, Boyce et al. 1995). Contamination at harvesting or packing stages was considered a potential factor. The growth of this pathogen on watermelon has also been recorded (Fredlund, Back et al. 1987).

(c) *E. coli* O157

The world's largest ever reported outbreak of *E. coli* O157:H7 to date occurred in Japan in 1996 and was linked to the consumption of raw radish sprouts served in school lunches. In total 6,000 people were affected and three deaths resulted (European Commission Scientific Committee on Food 2002).

A number of *E. coli* O157:H7 infections in the US have been epidemiologically linked to the consumption of lettuce. In 1995, contamination with irrigation water or unsanitary handling of lettuce were the likely causes of an outbreak associated with lettuce and cross-contamination from meat products was linked with another outbreak involving 'Iceberg' lettuce. Bovine and avian faecal contamination was also considered a potential factor in two outbreaks in 1996 involving 'mesclun mix' lettuce (O'Brien, Mitchell et al. 2000).

In the USA a large outbreak of *E. coli* O157:H7 was linked to the consumption of fresh spinach (Food and Drug Administration 2006). This was first reported by the CDC to the Food Standards Agency (CFSA) on 13 September, 2006. The following day consumers were alerted about the outbreak and advice to avoid bagged produce was later expanded to all spinach (including loose) or products containing spinach. In total there were 204 cases linked to the outbreak in a total of 26 affected states. This resulted in 104 hospitalisations and three deaths. The trace back investigation identified four implicated fields on four ranches located in the Monterey and San Benito counties in California. The outbreak O157:H7 strain was identified from cattle faeces on one of these ranches and from samples taken from a stream as well as from the faeces of wild pigs on the implicated ranches. Evidence that wild pigs had access to the spinach fields was also found. Work continues on gaining more information as to the source and

mechanism of contamination. Advice to consumers stressed that cooking at 70°C for 15 seconds would kill any *E. coli* O157:H7 present, but recognized that the majority of the spinach involved in the outbreak was consumed as a salad leaf. The risk of cross-contamination was described, with consumers being warned to avoid cross-contamination of fresh spinach with other foods and food contact surfaces. The use of warm soapy water to wash hands, utensils and surfaces after handling spinach was advocated (Food and Drug Administration 2006).

E. coli has been shown to survive on salad vegetables at refrigeration temperatures and grow at temperatures indicative of temperature abuse. The survival and growth on fruits such as watermelons, cantaloupe melons, apples and oranges has also been reported (Everis 2004).

(d) *Listeria*

The growth of *Listeria monocytogenes* on a wide variety of vegetables including broccoli, cabbage, lettuce and cauliflower has been reported both under Modified Atmosphere Packaging (MAP) conditions and at refrigeration temperatures (Francis, Thomas et al. 1999). The ability of the pathogen to survive on more acidic products, such as chopped tomatoes, appears to be lower than that reported for *E. coli* or *Salmonella* (Everis 2004). Contaminated coleslaw was identified as the most likely cause of an outbreak of *L. monocytogenes* in 1981 in Canada (Schlech, Lavigne et al. 1983).

(e) Spore-forming bacteria

Psychrotrophic strains of *Bacillus* and *Clostridium* are a potential hazard associated with chilled products. The main source of contamination is the soil. Cases of botulism that have been linked to fresh produce are very rare (Hauschild, 1992). However, outbreaks involving cooked/processed vegetable products (e.g. garlic in oil, mushrooms) have been reported (De Roeve, 1998).

(f) Protozoa

The protozoan pathogens most commonly associated with outbreaks involving fresh produce are *Cryptosporidium*, *Cyclospora* and *Giardia*. The oocysts of these organisms survive well in the environment and are resistant to chlorination in water supplies. The main routes of contamination are through exposure from irrigation water and poor hygienic practices.

The parasite *Cyclospora cayentanensis* was linked to numerous outbreaks of cyclosporiasis associated with soft fruits and leaves in the late 1990s in Canada and the US (European Commission Scientific Committee on Food 2002).

However, in relative terms cyclosporiasis is a rare infection. It is estimated to be responsible for 0.1 percent of total foodborne infections (Mead, Slutsker et al. 1999).

Giardia lamblia was epidemiologically linked with an asymptomatic food handler in an outbreak involving sliced vegetables in a cafeteria in a corporate office building (Francis, Thomas et al. 1999).

(g) Viruses

Foodborne infection with viruses is generally mediated through the faecal-oral route, direct contact or via consumption of contaminated food or water. Hepatitis A and Norovirus are the most commonly reported viral agents in food (O'Brien, Mitchell et al. 2000).

Limited data are available describing the survival of virus particles on fresh produce (Francis, Thomas et al. 1999), however, research funded by the FSA has demonstrated the potential for the prolonged survival on fresh fruit and vegetable produce.

Frozen raspberries have been linked to Hepatitis A infections in the UK (O'Brien, Mitchell et al. 2000). In 1998, 202 cases of Hepatitis A in Kentucky were linked to lettuce that was widely distributed commercially (Rosenblum, Mirkin et al. 1990).

(h) *Campylobacter*

Although animals and birds are natural reservoirs for human pathogenic *Campylobacter* and the organism is also associated with water supplies, the potential for cross-contamination from meat and poultry during food preparation has also been recognised (European Commission Scientific Committee on Food 2002).

C. jejuni has been shown to survive on a variety of fruit and vegetables for sufficient periods to cause food poisoning (Everis 2004).

At retail level, a large survey of over 3,000 samples of RTE organic vegetables failed to detect the pathogen (Sagoo, Little et al. 2001) suggesting that contamination through the food supply chain is not a significant issue. In a retrospective cohort study of sporadic cases of campylobacteriosis, the consumption of salad vegetables was found to be a risk factor which was most likely attributed to cross-contamination during food preparation (Evans, Ribeiro et al. 2003).

Microbiological Surveys of Fresh Produce

In the US, the Food and Drug Administration (FDA) domestic survey found that one percent of fresh produce samples (11 out of 1028) were contaminated with either *Salmonella* or *Shigella* (*E. coli* O157 was not detected). In the same survey, four percent of 1,003 samples of imported produce were contaminated with a pathogen with 80 percent (35 samples) testing positive for *Salmonella* and 20 percent (nine samples) positive for *Shigella* (Everis 2004).

In the UK, 99.5 percent (3185 of 3200 samples) of RTE organic vegetables from retail outlets were found to be of satisfactory and acceptable quality (Sagoo, Little et al. 2001). Unsatisfactory results were recorded from 15 samples where *E. coli* and *Listeria* spp. were in excess of 10^2 CFU g⁻¹. The study concluded that overall agricultural, hygiene, harvesting and production practices were good.

A similar study was conducted a year later in 2001 that involved the testing of bagged prepared RTE salad vegetables (Sagoo, Little et al. 2003). The vast majority (3826 of 3852; 99.3 percent) were of satisfactory or acceptable microbiological quality, whilst 20 (0.5 percent) of the samples were of unsatisfactory microbiological quality because of *E. coli* or *Listeria* spp. counts in excess of 10^2 CFU g⁻¹. More importantly, six samples (0.2 percent) were of an unacceptable microbiological quality because of the presence of *Salmonella* (five samples, one of which was *S. Newport* PT33 that was subsequently linked with 19 cases of human infection where strains had a unique plasmid profile identical to that isolated from the salad) or *L. monocytogenes* (where the level was 660 CFU g⁻¹). The authors concluded that these results highlighted the necessity for good hygienic practices from farm to fork to prevent contamination and/or bacterial growth in such salad products.

3.2.3 Preventing Microbial Contamination along the Food Chain

There are a number of sources of contamination, all of which must be controlled in order to prevent or minimise microbial contamination of fresh produce. The key areas where microbial contamination can occur are in the field; during harvesting and processing; and in the home. Each of these areas is outlined below.

3.2.3.1 Preventing microbial contamination in the field

Soil

Many food pathogens are commonly found in soil where the edible portion of vegetables are grown either directly in soil (root vegetables) or in close proximity to the soil (leafy vegetables) and where there is the potential for direct contamination during growing.

The contamination rate and survival of bacteria in soil appears to be dependent on several factors including soil type; moisture content; ultraviolet light exposure; temperature; and presence or absence of a ground crop. It is difficult to eliminate the risk of soil-borne contamination from vegetables, however, thorough washing prior to packaging should serve to remove as much soil as possible.

With respect to fruit products, these can be contaminated via soil if the fruit has dropped from trees. Therefore, the practice of using dropped or fallen fruit should be avoided, as additionally the product may have become bruised or the skin may have been broken, thus facilitating the internalisation of pathogens.

Animals, insects and birds

Transmission of pathogens can occur directly from animals, birds and insects. Many animals can act as reservoirs for human pathogens and if these animals come into contact with fresh produce, contamination can occur. The UK Fresh Produce Consortium Guideline (Fresh Produce Consortium 1998) has recommended that animals should be prevented from entering fields and that measures should be taken to prevent animal waste contaminating crop fields or water supplies during heavy rainfall.

Animal waste and sewage use

Animal waste is added as a fertiliser to soil to provide a nutrient source required for plant development. In some instances, such as organic farming, animal waste may provide the primary source of nitrogen (US FDA 2001). The FSA has produced draft guidelines for growers to minimise the risks of microbiological contamination of RTE crops (FSA 2005a). The guidelines points out a range of measures that can help kill pathogens that are present in manures and slurries including:

- exposure to sunlight and ultra-violet rays;
- high temperatures (above 55°C);
- low acid or high alkaline conditions (use of quick lime or slaked lime to raise pH levels);
- drying; and
- the passage of time (though bacteria such as *E. coli* can survive in soil for several months).

The draft guidance recommends a package of measures before, during and after the growing season including:

- careful selection of site of fields;
- lay-off periods between application of manures and slurries before harvest;
- not allowing livestock to roam on land where crops will soon be grown or harvested;
- recommendations for storing manures and slurries; and
- the use of potable water for washing produce

The Food Safety Authority of Ireland (FSAI) has also issued guidance on the use of farmyard manure, compost and faecal material in the fresh produce supply chain in ROI (FSAI 2001).

Water

Within crop production many practices require the use of water including irrigation, pesticide application, produce washing and cooling systems (Groves, Davies et al. 2002). Water can be a potential source of pathogen contamination and there are many organisms that can be transmitted via water, including viruses. These organisms can be shed in faeces and can contaminate water courses from animals directly or from sewage that has run off into water courses. The important issues relating to irrigation and pathogen contamination of RTE produce are:

- amount of water applied (this will affect bacterial levels applied);
- interval between application and harvest (this will influence pathogen survival rate); and
- microbiological quality of the water.

It is recommended that growers should identify the sources of water used for a particular purpose and minimise contamination from livestock, run-off, heavy rainfall and excess irrigation. It is also recommended that the microbial and chemical quality of the water is tested at appropriate intervals.

The FSAI have issued guidance on the use of water in the fresh produce supply chain and in particular on how to minimise the contamination of water used (FSAI 2001).

3.2.3.2 Preventing microbial contamination during harvesting

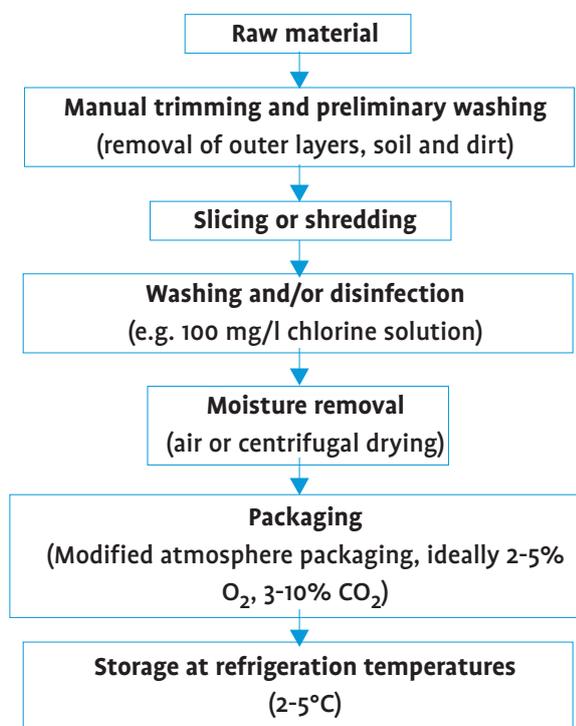
There are a number of steps that are taken to prevent the contamination of produce during the harvesting stage. These include measures to avoid contamination from field workers, harvesting equipment, water and transport vehicles (Chilled Food Association 2002). Field worker hygiene is important as hands are used in much of the harvesting process. Also with a view to preventing cross-contamination during harvesting, thorough cleaning and decontamination of equipment, containers and transport vehicles must be undertaken.

3.2.3.3 Preventing microbial contamination during processing steps

There are a number of steps involved in the processing of RTE fruit and vegetables (Figure 3.2); however the process varies depending on the nature of the produce and also the final product. This section describes the main steps that occur during the processing of fresh produce and also the main methods of reducing/eliminating contamination within each.

Fig 3.2 Typical flow diagram for the production of minimally processed vegetables

Francis, Thomas et al. (1999)



It is important that hygienic practices are followed throughout the processing of fresh produce and that raw materials and finished product are stored and handled in such a manner as to prevent contamination and damage which may lead to internalisation of organisms. It is also critical that the temperature of processing is controlled to prevent product spoilage and also to prevent the growth of pathogens.

Trimming and peeling

Most leafy salad vegetables are trimmed to remove stalks, cores and outer leaves before they are further processed. These procedures tend to be manual so consequently worker hygiene is important to prevent cross-contamination. It has been recommended that, after trimming, the edible portions should be conveyed to a segregated, hygienic, temperature-controlled area within ten minutes for further processing (Day 2001).

Most root vegetables and fruits, such as oranges, apples, melons and pears require peeling. These produce types are usually washed in potable/disinfected water prior to peeling and damaged parts are generally removed. In order to prevent structural damage, the peeling process should be as gentle as possible. Manual peeling causes less damage but this is not as economically viable so the use of a sharp knife blade is recommended. This will cause less damage and cross-contamination (Ahvenainen 1996).

Additionally, peeling machinery needs to be thoroughly cleaned and disinfected regularly to avoid microbial build up, growth and subsequent contamination of the produce.

Cutting and slicing

There are many machines which can grate, chop, slice, shred or chip fresh produce. It is important to reduce the level of contamination on the surface of produce by washing or disinfecting to prevent cross-contamination of internal tissue.

Internalisation of pathogens in fresh produce

The internalisation of pathogens in fresh produce is a concern to the food industry because they are less likely to be removed during post-harvest washing than surface contaminants (Aruscavage, Lee et al. 2006). *E. coli* O157:H7 that was inoculated into manure added to planting soil has been shown to contaminate and survive on lettuce plants grown in that soil. The pathogen was observed to be present within the plant tissues at a depth of up to 45mm (Solomon, Yaron et al. 2002). It has also been reported that *E. coli* O157:H7 was internalised in cress, lettuce, radish and spinach seedlings that had been contaminated as seeds. Mature plants did not remain internalised, however (Jablasone, Warriner et al. 2005).

Some produce items that have a higher water content, e.g. unwaxed apples, celery and tomatoes, are susceptible to micro-organisms entering the skin via the stomata and through stem scars on the calyces of fruits. Bacteria can enter fruits through damage such as puncture wounds and splits.

Bacteria can also be internalised via waterborne contamination. This can occur when fruits are put into a wash tank and water is taken up into fruits, particularly when the fruits are warm and the wash water is cold.

Internalisation of potential pathogens is a problem as they will not be removed by surface washing. Due to the risk of internalisation of pathogens, dropped or bruised fruits should not be used and practices which damage produce should be minimised. It is important to note that because of the potential for internalisation of pathogens, that the prevention of contamination at the pre-harvest stage may be arguably considered to be more critical than post-harvest decontamination.

Decontamination

All efforts should be taken to harvest fresh produce that is of the highest microbiological quality possible. As indicated above, however, there is some potential for RTE product to become contaminated with pathogens during the growing and harvesting stages. An effective decontamination stage is therefore essential prior to packaging to help reduce the level of pathogenic and spoilage organisms in RTE produce.

Figure 3.3 Decontamination techniques

Acidified sodium chlorite	Hydrogen peroxide
Acids	Iodine
Alkali	Ionisation
Biocontrol	Irradiation
Bromine	Natural compounds
Chlorine	Ozone
Chlorine dioxide	Photodynamic inactivation
Combination treatments	Removal by brushing
High pressure	Trisodium phosphate
Hot water	Ultrasound

Adapted from Seymour (1999) and US FDA (2001)

There are a number of decontamination techniques available, as detailed in Figure 3.3.

The most common compound used for the commercial disinfection of fresh produce is chlorine, with free chlorine concentrations of 50 – 100 ppm being used frequently. Initial removal of debris and organic matter is a prerequisite before the decontamination step as such material will reduce the efficacy of the disinfectant. It is the hypochlorous acid that is the active biocide and its concentration in the solution is pH dependent. At pH 7, 78 percent of hypochlorous acid remains in solution and for this reason citric acid is commonly used to maintain the pH at such levels. Maximum solubility of chlorine is achieved in water at about 4°C. However, the temperature of the chlorinated water should be at least 10°C higher than that of the fruits or vegetables to achieve a positive differential, thereby minimising the uptake of wash water through stem tissues and open areas in the skin or leaves, whether due to mechanical damage or naturally present e.g. stomata (Beuchat 1998).

Research funded by the FSA demonstrated that the removal of virus particles by washing in chlorinated water (100 ppm) was similar to that found with bacteria (reduction by one to two log cycles). The use of agitation marginally improved the sanitisation, but increasing the wash time above two minutes had little if any benefit. The researchers cautioned that if contamination levels are high, it is likely that after washing, sufficient virus particles would remain to cause infection (FSA 2004).

Further to the decontamination step, the washing process should include a final tank stage using non-chlorinated rinse water which has been chilled to 1°C to 2°C. This will remove traces of chlorines, give the product a final wash and also very importantly, reduce the product temperature to below 5°C, thus increasing its shelf-life (FSAI 2001).

Moisture removal

Once produce is washed, excess water needs to be removed as it could otherwise promote microbial growth. This can be achieved using a range of dewatering systems such as spin dryers, racks and sieves. It is important that the dewatering process is gentle so as to prevent damage which could lead to a deterioration in quality (Everis 2004).

Packaging

Fresh produce is highly perishable and has a shelf-life of anything from one to ten days at chill temperature, but this can be highly dependent on product type (Day 2001). Therefore technologies to extend the shelf-life are of great economic importance to the fresh produce industry.

Ways in which shelf-life can be extended include the use of MAP or Controlled Atmosphere Packaging (CAP). With MAP the gas composition is not controlled, whereas with CAP the gas atmosphere is kept constant.

MAP is defined as an atmosphere created by altering the normal composition of air to provide an atmosphere capable of extending shelf-life (Phillips 2006). In MAP, gases such as oxygen, carbon dioxide and nitrogen are used to alter the composition of the atmosphere around the product so that the storage life can be extended. The product is then sealed in a wrap like polyethylene, polypropylene, polyvinyl chloride or edible film.

CAP results in a much more stable atmosphere than MAP but requires gas-impermeable packaging, such as metal or glass. As a result it is more expensive and is not as widely used as MAP.

Tissue disruption caused by processing results in elevated respiration and transpiration, which can lead to rapid deterioration. In addition, cut tissues release nutrients that support the growth of micro flora present on raw produce. The O₂ level in packs is usually kept between one and five percent, which will reduce the respiration rate and, therefore, oxidative breakdown of fruits and vegetables (Lee, Arul et al. 1995). Respiration uses O₂ and typically produces CO₂ therefore making packs anaerobic. O₂ levels below eight percent also reduce the level of ethylene, which delays ripening and maturation. However, low levels of O₂ can increase anaerobic respiration and sensory degradation.

Given that MAP alone is not sufficient to prevent pathogen growth, chilling is extremely important and Hazard Analysis Critical Control Point (HACCP), Good Manufacturing Practice (GMP) and Good Agricultural Practice (GAP) should be in place to prevent pathogen contamination.

Infected food handlers

The role of infected food handlers in the transmission of pathogenic bacteria and viruses through RTE fruit and vegetables has been highlighted.

According to the Hygiene Package (specifically Regulation (EC) No 853/2004) persons suffering from gastrointestinal symptoms are required to report their condition to their employer, be excluded from handling food and seek medical advice before being allowed to return to their duties. The requirement for suitable sanitary conditions, such as adequate hand washing facilities, at all stages within the food production chain, including primary production, is also stipulated. It is the legal responsibility of the food business owner to ensure that these rules are applied.

A number of guidelines have been issued on IOI in relation to food handler hygiene (Department of Health 1995; National Disease Surveillance Centre 2004). Specific advice in relation to food handler hygiene for those involved in the fresh produce supply chain has been issued in ROI (FSAI 2001).

3.2.3.4 Preventing microbial contamination in the domestic setting

Washing or decontamination

Fresh fruit and vegetables are eaten in their raw, uncooked form and it is thus essential that these commodities are free from contamination, whether chemical or microbiological in nature. Current advice from the Advisory Committee on Pesticides, issued through the FSA, concluded that washing or peeling of fruit and vegetables is not required as a protection against pesticide residues. The FSA, however, advised that it was prudent to wash fruit and vegetables before consumption for reasons of general food hygiene (FSA 2002). **safefood** also advises consumers that fresh produce should be washed before eating.

A study investigating the efficacy of home washing methods in removing surface microbial populations from fresh produce, recommended that consumers should be instructed to rub or brush fresh produce under the cold running tap before consumption. Pre-soaking (immersing) in water before rinsing was found to significantly reduce bacterial numbers in apples, tomatoes and lettuce. Wiping apples or tomatoes with a dry or wet paper towel was shown to be less effective than soaking or rinsing (Kilonzo-Nthenge, Chen et al. 2006).

Temperature control

The main growth limiting factor in minimally processed fruit and vegetables is temperature. At temperatures below 5°C, bacteria will multiply slowly, although this treatment may be less effective against *L. monocytogenes* (Everis 2004). For this reason, the maintenance of the cold chain is essential for consumers to minimise the potential for the growth of the microflora present in minimally processed fruit and vegetables.

Storage and handling to prevent cross contamination

The potential for cross-contamination from raw meat and poultry to RTE fruit and vegetables is well recognised. It is essential that all steps are taken during food storage and preparation to prevent such cross-contamination from taking place. This involves advising those involved in food preparation to correctly wash their hands before and after handling raw meat and poultry.

Raw and RTE foods should be kept completely separate by adequately decontaminating utensils and cutting boards between use (or using separate utensils and cutting boards). This was highlighted in a UK study (Redmond, Griffith et al. 2004) which found that in a domestic kitchen, 29 percent of food preparation sessions resulted in positive *Campylobacter* isolates from prepared salads, cleaning materials and food-contact surfaces. Typing results showed that specific *Campylobacter* strains isolated from prepared chicken salads were the same as those isolated from raw chicken pieces, indicating microbial transfer during food preparation. As previously mentioned in Section 3.2.2.4, a retrospective study of sporadic cases of campylobacteriosis, found that the consumption of salad vegetables was a risk factor which was most likely attributed to cross-contamination during food preparation (Evans, Ribeiro et al. 2003).

On the other hand, however, a large retail survey of RTE organic vegetables failed to detect the pathogen (Sagoo, Little et al. 2001) suggesting that contamination through the food supply chain is not a significant issue.

3.2.4 Sprouted seeds

Sprouted seeds (e.g. cress, mustard, alfalfa) represent a unique hazard, as the germination process results in the inhibitory barrier of the seed coat being breached. This can potentially allow any pathogens present to grow on nutrients from the sprouted plant. For this reason, and in response to a number of large food poisoning outbreaks associated with such products (Section 3.2.2), special precautions are required in the decontamination of seeds and their germination.

The FSAI recommends:

- the treatment of seeds with chemical washes and heat treatment to reduce the number of pathogens present on seeds;
- the pre-soak cleaning of seeds to remove any foreign matter and organic matter;
- the surface decontamination of seeds in water using a high level of decontaminant (e.g. 100 to 200 ppm total chlorine);
- the use of chlorinated water for germination;
- the use of treated water for irrigation during the growth of the sprout;
- the washing of post-harvest sprouts with chlorinated water to remove the seed coat and reduce microbial load; and
- the storage of final product at a temperature of 3°C (FSAI 2001).

3.2.5 Spoilage

Food that has been damaged or injured so as to make it undesirable for human use may be described as being spoiled. Such spoilage may be caused by insect damage, physical injury such as bruising and freezing, enzyme activity or that caused by microorganisms.

Despite the intrinsic mechanisms that plants have evolved to protect against harmful microorganisms, the destruction of plants by microbes is a common occurrence, particularly when growing and harvesting conditions are not optimal. About two thirds of such spoilage of fruits and vegetables is caused by moulds, involving members of the genera *Penicillium*, *Aspergillus*, *Sclerotinia*, *Botrytis* and *Rhizopus* (Jay 1986).

3.2.6 Food Safety Regulation of the Fruit and Vegetable Supply Chain

3.2.6.1 Legislation

On January 1, 2006 new hygiene legislation, commonly referred to as 'The Hygiene Package' came into effect. It covers all aspects of the food chain from a food hygiene perspective (see Appendix D).

Commission Regulation (EC) No 852/2004 sets out the requirements for the hygiene of foodstuffs. Article Four of this regulation sets out the general and specific hygiene requirements. These include compliance with microbiological criteria for foodstuffs; compliance with temperature control requirements for foodstuffs; maintenance of the cold chain and sampling and analysis. Article Five sets out requirements in relation to HACCP.

Annex One of Commission Regulation (EC) No 852/2004 sets out the hygiene requirements for foodstuffs, including the primary production of plant products. The latter include the following:

- The control of hazards in primary production and associated operations including measures to control contamination arising from the air; soil; water; feed; fertilisers; veterinary medicinal products; plant protection products and biocides; and the storage, handling and disposal of waste.
- Food business operators producing or harvesting plant products are to take adequate measures, as appropriate:
 - to keep clean and, where necessary after cleaning, to disinfect, in an appropriate manner, facilities, equipment, containers, crates, vehicles and vessels;
 - to ensure, where necessary, hygienic production, transport and storage conditions for, and the cleanliness of, plant products;
 - to use potable water, or clean water, whenever necessary to prevent contamination;
 - to ensure that staff handling foodstuffs are in good health and undergo training on health risks (as mentioned in Section 3.2.3.2, p.39);
 - as far as possible to prevent animals and pests from causing contamination;
 - to store and handle wastes and hazardous substances so as to prevent contamination;
 - to take account of the results of any relevant analyses carried out on samples taken from plants or other samples that have importance to human health; and
 - to use plant protection products and biocides correctly, as required by the relevant legislation.

Annex 1 of Regulation (EC) 852/2004 also compels food business operators producing or harvesting plant products to keep records on (a) the use of plant protection products and biocides; (b) any occurrence of pests or diseases that may affect the safety of products of plant origin; and (c) the results of any relevant analyses carried out on samples taken from plants or other samples that have importance to human health.

Regulation (EC) 852/2004 requires all food businesses to be registered with the competent authority. It also stipulates that food business operators should apply the principles of the system of HACCP in order to identify critical control points that need to be kept under control in order to guarantee food safety. Food Business Operators must ensure that where and how the food is produced is hygienic, and that the premises are kept clean and properly equipped. Staff members must observe good personal hygiene practices, and be properly supervised and trained.

Commission Regulation (EC) No 854/2004 sets out the official controls on products of animal origin intended for human consumption.

Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs, specifies microbiological standards for the following pathogenic organisms:

- *L. monocytogenes* in RTE foods able to support the growth of *L. monocytogenes*, other than those intended for infants and for special medical purposes.
- *Salmonella* in RTE sprouted seeds, pre-cut fruit and vegetables and unpasteurised fruit and vegetable juices.
- *E. coli* in pre-cut fruit and vegetables and unpasteurised fruit and vegetable juices.

However, the legislation states that microbiological criteria, including sampling plans and methods of analysis, may be laid down if a need to protect public health arises.

3.2.6.2 Enforcement

The Department of Agriculture and Food is responsible for enforcing the provisions of Commission Regulation (EC) No 852/2004 in relation to primary producers of fruit and vegetables. Commission Regulation (EC) No 852/2004 has been given effect insofar as that Department has responsibility for its enforcement by the European Communities (Food and Feed Hygiene) Regulations 2005 (S.I. No. 910 of 2005), as amended by the European Communities (Food and Feed Hygiene) Regulation 2006 (S.I. No 387 of 2006). DAF is compiling a register of all primary producers of fruit and vegetables and a risk-based practical and effective enforcement regime is being developed (Department of Agriculture and Food 2006a).

The Department of Agriculture and Rural Development (DARD) Quality Assurance Branch carry out plant health inspections on horticultural produce to ensure that it is free from quarantine pests and diseases. These inspections can be carried out at any stage of the growing, packing or storage of the horticultural produce but does not include processing except in the case of potatoes where diseases such as Ring Rot or Brown Rot would be investigated to trace the supply route of any diseased material. DARD also carries out horticultural marketing inspections at grower, wholesale and retail level to ensure that horticultural produce complies with EU legislative standards (Gamble 2006).

Officers of DAF and DARD already carry out inspections and other control procedures on fruit and vegetables under EU and national plant health and marketing standards legislation. This includes the enforcement of EU quality standards covering most fruit and vegetables marketed in IOI through inspections at wholesale and retail level. While the focus of these standards is to ensure visual uniformity, they also require that the produce must be free of any visible foreign matter and damage caused by pests and diseases. The product must be fit for human consumption. The control measures are subject to audit by the FSAI/FSA and Food and Veterinary Organisation (FVO).

3.2.7 Codes of practice and guidelines

There are a number of codes of practice and guidelines that have been developed in both jurisdictions to ensure the safety of fruit and raw vegetables produced on IOI.

As indicated earlier in this document (Section 3.2.3), the FSA have produced draft guidelines for growers to minimise the microbial contamination of RTE crops (FSA 2005a).

In NI DARD has produced guidance notes on the Control of Pollution (silage, slurry and agricultural fuel oil) Regulations 2003 and Codes of GAP for the prevention of pollution of water (DARD 2003a), air and soil (DARD 2003b), respectively.

The FSAI has issued a code of best practice for food safety in the fresh produce supply chain designed to minimise the risk of foodborne illness resulting from the consumption of fruit and vegetables (FSAI 2001). This code makes reference to the control of hazards associated with fruit and vegetable production including water, biosolids (manure, compost and faecal material), hygienic practice and the safe use of pesticides and biocides. The code also identifies the critical control points associated with ensuring prepared vegetable safety during processing, storage and retail sale. The particular microbial hazards associated with the productions of sprouted seeds are also included in the code as are the steps that must be taken to ensure the safe production of both seeds and sprouts. In the UK the Fresh Produce Consortium has issued guidelines to producers for the control of microbial hazards (Fresh Produce Consortium 1998) while the Chilled Food Association has issued microbiological guidance for produce supplied to chilled food manufacturers (Chilled Food Association 2002).

A set of guidelines for the use of chlorine in fresh produce washing has also been developed by Campden and Chorleywood Food Research Association to assist companies producing, supplying and packing fresh produce (Campden and Chorleywood Food Research Association 2002).

3.3 Chemical Residues and Contaminants

3.3.1 Introduction

As with other foodstuffs, fruit and vegetables are potential dietary sources of chemical residues (as defined under EU Directive 91/414/EEC) and contaminants (as defined under EU Council Regulation 93/315/EEC). Both can occur under growing, harvesting or post-harvest conditions and result from intentional (such as during pesticide application) or unintentional (such as those resulting from fungal contamination) exposures, respectively. Fundamentally, there are three exposure scenarios: (1) residues resulting from deliberate pre-harvest chemical treatments; (2) residues resulting from deliberate post-harvest chemical treatments; and (3) unintentional contamination.

3.3.2 Residues resulting from deliberate pre-harvest chemical treatments

3.3.2.1 Pesticides

A pesticide is any substance or mixture of substances used to prevent, destroy or repel a pest. Pesticides are, by definition, harmful to living organisms. They are mostly man-made substances and preparations but also include certain natural compounds such as plant-produced phytotoxins and microorganisms such as the microbial insecticide *Bacillus thuringiensis*.

Pesticides are categorised according to their target: those targeted at plants are categorised as herbicides, while those targeted at moulds and fungi are categorised as fungicides. Other categorisations include insecticides (insects), molluscicides (molluscs), rodenticides (rodents), avicides (birds) and soil-sterilants.

EU plant protection product legislation

Within the EU, pesticide authorisation and use is regulated by two main pieces of legislation; the Plant Protection Products Directive (91/414/EEC) and the Biocides Directive (98/8/EC), as amended.

Directive 91/414/EEC covers all pesticide substances, preparations and organisms used in the selective protection of plant species, including raw vegetables and fruit-producing species. This directive was transposed into ROI law as Statutory Instrument No. 139 of 1994 and into UK (NI) law as the Plant Protection Products Regulations (PPPR) of 1995. In practice, the PPPR applies to new active substances coming onto the UK market and existing reviewed active substances that have obtained Annex I listing. Existing active substances awaiting review are controlled under the Control of Pesticides Regulations (COPR) (SI 1986/1510).

EU plant protection product authorisation procedure

Directive 91/414/EEC established a harmonised process for the authorisation of pesticide active substances to be used for plant protection purposes. The criteria necessary to facilitate authorisations are set out in Annexes II and III to the Directive and procedures were formalised as “uniform principles” which are specified within Annex VI of the Directive (Council Directive 97/57/EC establishing Annex VI to Directive 91/414/EEC). The onus to fulfil these criteria was placed with the company wishing to market the plant protection active substance. These include a concise specification of the active substance; its physical and chemical properties; data on the target organisms and conditions of use, which inform GAP specifications and hazard identification and risk assessment for adverse effects on human health (consumers, workers and bystanders); the environment and non-target species. Similar data on at least one marketable product containing the active substance must also be supplied by the company.

The information is evaluated by a Member State(s) chosen under the EU review programme for pesticide active substances (set out in Commission Regulation (EC) No 451/2000). Under this programme, each MS has been assigned responsibility for evaluating existing active substances commensurate with the resources available in each state. Companies wishing to market a new active substance (ie. not on the market on or before 25 July 1993) can select a MS as rapporteur for assessment of their dossier on behalf of the European Food Safety Authority (EFSA).

Following an initial completeness check that all required data has been submitted, the rapporteur has one year in which to submit a detailed evaluation, known as a draft assessment report, to EFSA. This report is subsequently peer reviewed by experts from other MS after which a recommendation for inclusion or rejection is sent by EFSA to the European Commission. This recommendation is discussed by the MS in the framework of the Standing Committee on the Food Chain and Animal Health (SCFA). Where necessary, the Scientific Panel is consulted before the SCFA can deliver an opinion on whether or not the active substance should be included in Annex I to Directive 91/414/EEC. Unsuccessful applications are excluded from Annex I and are subsequently prohibited from the EU marketplace.

As of January 2004 there were 75 active substances listed in Annex I while a further 350 had been refused inclusion to the annex. These refusals may have resulted from concerns over possible health or environmental effects of the active substance, or on the basis that it was not sponsored by any company under the requirements set out in the Directive.

The number of authorised pesticide active substances in the EU continues to fall as a direct result of the review programme. By 2008 it is anticipated that only 350 authorised pesticide active substances will remain. Currently there are over 800 active substances registered throughout the world for use in plant protection products alone. At present, there is in the region of 860 plant protection products formulated from approximately 230 active substances on the ROI market, although only a proportion of these would be used in the cultivation of fruit and vegetables (DAF 2006).

Pesticide active substances are almost invariably marketed as product formulations. Even if the active substance is listed in Annex I to the Directive, permission to market products containing this active substance remains the prerogative of the designated national competent authority in each MS. It is possible that a plant protection product may contain more than one active substance only one of which is listed in Annex I.

The Directive provides the MS with the flexibility to grant permission based either on an evaluation of submitted data or the experience in another MS where the product is already marketed (‘mutual recognition’). Plant Protection Products with active substances not yet included in Annex I are covered by transitional arrangements whereby a MS may authorise new products containing active substances which were already on the EU market on 25 July 1993. They can also provisionally authorise products containing new active substances in advance of Annex I listing for a period of up to three years or accommodate existing national authorisations pending completion of the review within a timeframe of December 2008.

Within ROI, the Pesticide Control Service (PCS) of the DAF is the designated competent authority for the evaluation and national authorisation of plant protection (and biocide) products. In the UK, the Pesticides Safety Directorate

(PSD) is the responsible authority for plant protection product authorisations. The PSD is an executive agency of the Department for Environment, Food and Rural Affairs (DEFRA). DARD is the responsible authority for the administration in NI of the UK-wide authorisation programme and in this context it reports to Defra. The majority of products approved for use in Great Britain are subsequently approved for use in NI.

Toxicological testing requirements for plant protection products

Annexes II and III of Directive 91/414/EEC specify the toxicological tests that are required for the active substance and sample product, respectively, before the active substance can be considered for inclusion in Annex I or that particular product marketed in the EU. The purpose of these tests is to evaluate the risks for operators and bystanders associated with the handling and use of the plant protection products containing the active substance, as well as the risk for consumers arising from residual traces remaining in food and water. These tests clarify the behaviour of the active substance in the body; the toxic effects of single high doses and multiple repeat low doses of the active substance; skin and eye irritation and skin sensitization potentials; genotoxicity; carcinogenicity; reproductive toxicity; and, where necessary, the neurotoxicity and immunotoxicity potentials of the active substance. Medical data from manufacturing plant personnel, clinical cases, poisoning incidents and epidemiological studies are also taken into account. Of the parameters deduced from this data, two are important in terms of consumer protection, the acceptable daily intake (ADI) and the acute reference dose (ARfD).

The ARfD is the amount of plant protection product residue in food (or water) that can be ingested over a short period of time, usually during one meal or one day, without any ill effects. The ADI is a similar quantity but is established on the basis of daily ingestion over a lifetime. It is also critical to the establishment of maximum residue levels (MRL) for plant protection product residues in food.

Maximum residue levels

With regard to plant protection products, the MRL is the maximum permissible concentration of the active substance or its metabolites (known collectively as 'residues') in a food. MRLs are set for all types of raw food and some processed food commodities that are destined for human or animal nutrition.

In establishing an MRL, regulators take a number of factors into consideration. These include GAP recommendations, data on consumer residue intake, and the physico-chemical and biological properties of the chemical in question (including the ADI and ARfD). Trade issues and the experiences of other national and international regulatory agencies are also drawn on (Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC).

The MRL is primarily a check that GAP is being adhered to during the production of fruit and vegetables. (Note, GAP specifications do not necessarily include the caveat that the final product, as presented to the consumer, should be residue-free). It also serves to regulate trade in food commodities treated with pesticides. MRLs are not safety limits for human health although the latter are taken into consideration when establishing the MRL which is invariably lower. Therefore, a violation is not necessarily a cause of concern to public health. There are currently 182 MRLs for plant protection active substances used in fruit and vegetables in ROI (DAF 2006).

Therefore, as already mentioned in Section 3.2.3.4 (p.40), GAP is protective against exposures to pesticide residues in excess of the MRL. Washing or peeling fruit and vegetables is not required as a protection against pesticide residues; it is however advisable for reasons of good hygiene.

Monitoring for plant protection product residues in ROI

With regard to plant protection products, the annual monitoring programme for residues in food in ROI is undertaken by DAF on behalf of the FSAI. The monitoring programme is based on the recommendations of the EU Commission, Irish consumer dietary patterns, information from previous monitoring programmes, pesticide sales data, and food preparation data (Irish Universities Nutrition Alliance 2001; EFSA Surveillance Authority 2004). Both domestically-produced and imported products are sampled.

The primary goal of the monitoring programme is to ensure that the GAP specifications associated with each plant protection product have been adhered to. These should ensure that unacceptable residue levels are not

experienced. Where breaches of established MRLs are detected, PCS has the authority to confiscate and destroy the affected produce. Prosecutions may follow. The residue levels are scrutinised for possible breaches of either ADI or ARfD and if a risk to the consumer is identified a rapid alert may be issued by the FSAI. The monitoring programme also targets plant protection products and other chemicals that are banned in the EU.

Results of monitoring for plant protection product residues in ROI

In 2004, 853 routine samples of 77 different species (or types) of fruit and vegetables (including ten types of fruit juice and popcorn) were analysed for pesticide residue content (Department of Agriculture and Food 2006b). The total number of each variety of fruit and vegetables analysed ranged from one to 88 (for example, one variety of pomegranate to 88 varieties of apples). In the case of 48 (62 percent) of these fruit and vegetable species, over 50 percent of samples contained detectable levels of pesticide residues. Approximately 27 percent of all samples were grown in ROI, 44 percent were imported from other EU countries and 29 percent were imported from Third Countries. All samples were analysed for up to 118 pesticides and metabolites. Approximately 52 percent contained one or more detectable levels of pesticide residues and a total of 53 different pesticides were detected. MRLs were available for 42 of these compounds with the limit of analytical detection being the default MRL for the remaining 11 compounds. Approximately 96.6 percent of samples did not breach MRL requirements. The estimated daily intake of pesticide residue where an MRL breach was recorded would not exceed the ADI for that pesticide and therefore did not present a public health concern (Department of Agriculture and Food 2006b).

In addition to the monitoring programme, 18 samples of fruit (five species) and vegetables (four species) were taken as part of a targeted sampling programme to follow-up on MRL breaches recorded in 2003. These samples were of ROI, EU and Third Country origin. Eleven had detectable residue levels but again these did not present a public health concern (Department of Agriculture and Food 2006b).

Monitoring for plant protection product residues in NI

The PSD is the national competent authority in the UK and NI for national authorisations and evaluations of pesticide products. Within the Directorate, the Pesticide Residues Committee (PRC) is an independent group of experts whose main function is to manage the annual pesticide residues surveillance programme throughout the UK. In this role they advise Government Ministers, the Chief Executives of the PSD and the FSA on all aspects of the monitoring programme.

In the 2004 monitoring programme 2348 of 3800 samples of fruit and vegetables collected from 24 sites in the UK (including NI) were analysed for 123 pesticide active substances (Pesticide Residues Committee 2005). Of the samples tested none were from NI. Residues were detected in 898 samples which, at 38 percent is lower than the positive rate in the ROI for the same year. MRL breaches were registered in 39 samples (six percent) of fruit and vegetables. Of these, concerns were expressed with regard to the level of inorganic bromide in UK-grown lettuce, endosulfan and methamidophos in Spanish lettuce and methomyl and triazophos in Thai beans. Although the ARfD was breached in all cases, a risk assessment concluded that harmful effects were unlikely with the possible exception of particularly sensitive children who could experience sweating; increased salivation; and/or stomach ache if exposed to a sufficient quantity of the Spanish lettuce.

3.3.2.2 Nitrate

Nitrate occurs naturally in most plants and vegetables. The concentration of nitrate in plants is influenced by a number of factors including species; fertiliser use; and variety and growing conditions, of which light is the most important. Poor light conditions can result in a lower rate of photosynthesis, creating an accumulation of nitrate in the plant tissues. This is particularly evident during winter production of some vegetables, especially spinach and lettuce.

Nitrate is a permitted food additive within the EU. Sodium and potassium nitrate (E251 and E252, respectively) can be added to certain meat, fish and cheese products and foie gras (Beuchat 1998). Between 70 and 90 percent of nitrate intake in the diet can be attributed to the consumption of vegetables.

Excessive nitrate intake can potentially have harmful effects including anaemia in adults and possibly

methemoglobinemia in infants (Fewtrell 2004). The toxicity of nitrate has been reviewed by both the European Commission's SCF and the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Both recommend an ADI of 3.7 mg/kg bw/day.

Commission Regulations 466 of 2001 and 563 of 2002 establish maximum permissible levels for nitrate in spinach (fresh, preserved, deep-frozen or frozen) and lettuce (fresh and iceberg). However, both regulations allow for an optional derogation from the limits for nitrate in lettuce and spinach providing the GAP requirements to ensure that the final nitrate level is as low as possible is adhered to. Although the derogation for lettuce ceased in January 2005, an extension is being sought based on the experience of growers in Northern Europe where light intensities are low, particularly during winter months. Belgium, ROI, the Netherlands and the UK have a derogation from the established levels for spinach, while ROI and the UK have a derogation from the established levels for lettuce, both until 2008 [under Commission Regulation (EC) No 1822/2005, amending Regulation (EC) No 466/2001 as regards nitrate in certain vegetables].

These regulations also stipulate that all MS must carry out monitoring for nitrate in lettuce and spinach and report the results annually to the European Commission.

The results of the UK monitoring programme for nitrate in fruit and vegetables have been published (FSA 2005b). The levels recorded were generally low and considered not to represent a safety concern based on the established ADI. Nevertheless, the need for the derogation provided for in the regulations was still evident as some growers experienced difficulty in adhering to the established maximum levels.

Lettuce and spinach are routinely monitored for nitrates in ROI, other fruit and vegetables are not however.

3.3.3 Residues resulting from deliberate post-harvest chemical treatments

3.3.3.1 Chlorine

Chlorine is used in the treatment of drinking water and the maximum allowable drinking water concentration in the EU (as set out in Council Directive 98/83/EC) is 250 mg/l (normal municipal tap water contains approximately 0.5 mg/l total chlorine). Chlorine is also used as an antimicrobial wash or spray in the raw fruit and vegetable industry where aqueous solutions typically in the order of 50 – 100 mg/litre are used. Chlorine is usually added as liquid chlorine or hypochlorous acid but chlorine dioxide and acidified sodium chlorite are also used. Processes generally incorporate a final rinse with chilled water containing up to 4 mg/litre free chlorine (ie. less than the chlorine concentration of tap water) (Committee on Toxicity 2005).

The EU Biocides Directive 98/8/EC includes compounds used to improve the hygiene of food stuffs and in this context covers treatment with chlorine. There are no maximum permissible levels expressed either for chlorine or its by-products, which can be generated on foodstuffs.

Chlorine is known to interact with organic matter present in water to generate a spectrum of by-products including trihalomethanes (chloroform, bromodichloromethane, chlorodibromomethane and bromoform), haloacetic acids, haloacetonitriles, haloketones, chloral hydrate and chloropicrin. The use of chlorine washes or sprays must comply with the legal definition of a processing aid, ie. they should not perform a function in the final product and should leave no residues that present a health risk (Council Directive 89/107/EC on the approximation of the laws of the Member State(s) concerning food additives authorized for use in foodstuffs intended for human consumption). ROI and UK legislation sanctions the use of chlorine as an antimicrobial treatment for non-organic fruit and vegetables with this caveat.

No assessment of the potential risks of chlorine and chlorination by-products from fruit and vegetable processing has been performed. In 2005, the UK Committee on Toxicity (COT) concluded that it was possible for the aforementioned disinfection by-products to be generated in foods treated by chlorination or ozonation. Prior to any assessment of the risk to human health, more accurate and comprehensive information on the nature and levels of the by-products formed are required. (An EFSA evaluation of the toxicological risks from disinfection of poultry carcasses with different compounds including chlorine dioxide and acidified sodium chlorite, found no evidence of chlorinated organic by-products and concluded their use presented no safety concern – (EFSA 2005)).

In addition, a comprehensive risk assessment will require reliable estimates of exposure to these by-products as well as the contribution to total exposure from non-dietary sources (as outlined in Council Directive 89/107/EEC).

The toxicological profiles of chlorination by-products are incomplete. Concerns have been expressed regarding their carcinogenic and reproductive toxicity potentials. However, the data so far remains inconclusive and is certainly not robust enough on which to base any potential changes to current processing/disinfection practices (Fawell 2000). A US Environmental Protection Agency (EPA) study on the carcinogenic activity of, and potential interactions between, different trihalomethanes in drinking water was also inconclusive (Pereira 2000).

In 1998 (and reiterated in 2004), COT concluded that there was insufficient evidence of a link between exposure to chlorination by-products in tap water and an increased risk of adverse reproductive outcomes (COT 2004a). While advocating further research in the area, the COT concluded that current efforts by water companies to minimise consumers' exposure to chlorination by-products remained appropriate, once these measures did not compromise the efficiency of drinking water disinfection (COT 2004b). Limits have been established for total trihalomethanes in drinking water in the EU under Council Directive 98/83/EC.

3.3.3.2 Iodine/Bromine

Iodine and bromine ions originate from the same chemical group as chlorine and as such, display similar reactivity. Their use as disinfectants in the processing of fruit and vegetables is limited, however, due to health and safety and environmental concerns in the case of bromine, and the potential for iodine to dye organic matter (Campden and Chorleywood Food Research Association Group 2004). The potential by-products of disinfection treatment with bromine are largely the trihalomethanes (bromodichloromethane, chlorodibromomethane and bromoform).

In 1997, results from the UK Total Diet Study indicated that fruit and vegetables are unlikely to contribute significantly to the total daily intake of these ions and concluded that these were no cause for health concerns (COT 2000a).

3.3.3.3 Ozone

The use of ozonated wash and flume water for microbial control during fruit and vegetable handling and processing has been shown to be efficacious in the control of several bacterial species (EFSA 2005). The use of ozonated waters has been generally recognised as safe (GRAS) in the US since 1997 (European Commission Scientific Committee on Food 2002). Nevertheless, there is still uncertainty with regard to the toxic effects of ozone, particularly its carcinogenic and genotoxic potentials (COT 2000b). However, as with most other disinfection treatments, no exposure or risk assessment has been performed on ozone exposure from treated fruit and vegetables.

Ozonation can lead to non-halogenated by-products, such as aldehydes (e.g. formaldehyde); ketoacids and carboxylic acids; and brominated compounds, including bromate if bromide is present.

Ozone has a faster sterilization and disinfection rate than chlorine. It is the disinfection method of choice for a number of municipal water treatment schemes including those of Paris since 1903 and Los Angeles since 1984 (Chem-Free Water Treatment Systems 2006).

3.3.3.4 Trisodium phosphate

In addition to its role as a disinfectant, trisodium phosphate is a permitted food additive in the EU (E339). Sodium phosphates are regarded as safe food additives both in the EU and the US. Nevertheless, the efficacy of trisodium phosphate as an antimicrobial agent for use on produce has been challenged (Beuchat 1998).

Trisodium phosphate rapidly dissociates into its constituent sodium and phosphate ions. The main health concern is the possibility of an effect on the calcium-phosphorous-magnesium balance in the body. JECFA has established a maximum tolerable daily intake (MTDI: a similar parameter to the ADI) of 70 mg/kg bw/day for trisodium phosphate.

No risk assessment has been conducted on the exposure to trisodium phosphate from fruit and vegetables. Its use as a disinfectant on poultry carcasses is not a cause for concern as the maximum exposure is in the order of four percent of the MTDI (EFSA 2005). It is highly unlikely that exposure from treated fruit and vegetables would exceed this value.

3.3.3.5 Quaternary ammonium compounds

These compounds are cationic surfactants which can penetrate organic material. Very little toxicological information is available on this group of compounds. The main hazard appears to be an irritation or corrosion potential at high concentrations (International Programme for Chemical Safety INCHEM 1999).

No assessment of exposure (and therefore risk of adverse effects) to these compounds from treated fruit and vegetables has been performed. Exposure estimates from other sources include an estimate of a non-toxic dose of 100mg per person per year through oral contamination from dish-washing detergents (Gloxhuber 1974). Quaternary ammonium compounds are most suited to surface disinfection for uncut fruit and vegetables which would subsequently be peeled before processing and consumption (EFSA 2005). However, quaternary ammonium compounds are not widely used in fruit and vegetable processing, so it is likely that exposure from this source is not a significant risk factor.

3.3.3.6 Organic acids

Organic acids, such as lactic acid and acetic acid, can potentially be used as surface washes for antimicrobial control on fruit and vegetables (EFSA 2005). These are naturally occurring compounds in fruit and vegetables and do not present a human health risk at the levels present from this source of exposure.

3.3.3.7 Hydrogen peroxide

The antimicrobial activity of hydrogen peroxide depends on temperature, pH and other environmental factors (EFSA 2005). An assessment of exposure (and risk) to hydrogen peroxide from fruit and vegetable consumption is not available. EFSA has stated that the maximum exposure to hydrogen peroxide from treated poultry, based on normal dietary exposure, does not represent a safety concern (EFSA 2005). In addition, JECFA concluded in a review of food additives, that the reactivity of hydrogen peroxide with organic matter would result in its rapid break down into acetic acid, octanoic acid, and water and therefore does not pose a risk (JECFA 2005).

3.3.3.8 Waxes

Under EU Council Directives 95/2/EC and 2003/114/EC, a number of wax coatings have been sanctioned for use on certain fruits and vegetables. These include beeswax (E901), candelilla wax (E902), carnauba wax (E903), shellac (E904), microcrystalline wax (E905), montan acid esters (E912) and oxidized polyethylene wax (E914). The function of these additives is to help retain moisture in fruit and vegetables during shipping and marketing; inhibit mould growth; prevent other physical damage; and enhance the appearance of the product. These additives are also used on snacks, nuts, coffee beans, dietary food supplements, chewing gum, and certain confectionery and chocolate coatings.

As with all food additives approved for use in the EU, these waxes undergo a rigorous scientific safety evaluation before being approved for use (Beuchat 1998).

Although the waxes are considered safe to eat, they are nonetheless indigestible. They cannot be removed by washing so, apart from the obvious choice of buying unwaxed commodities, consumers must peel fruit and vegetables if they wish to avoid eating the wax coating.

3.3.3.9 Irradiation

Food irradiation is a processing technique that exposes food to electron beams, X-rays or gamma rays, and produces a similar effect to pasteurisation, cooking or other forms of heat treatment, but with less effect on appearance and texture (World Cancer Research Fund (WCRF) and the American Institute for Cancer Research (AICR) 1997).

There are no food irradiation facilities on IOI, therefore any irradiated foodstuffs or ingredients on the IOI market are imported as there are no prohibitions or restrictions on the import of foods irradiated by other MS.

A combined WHO/FAO/International Atomic Energy Agency (IAEA) report concluded that irradiated food is both safe to consume and nutritionally adequate provided that the sensory qualities of food are retained and harmful microorganisms are destroyed (International Consultative Group on Food Irradiation 1999).

Two EC Directives relating to irradiated food have been implemented in MS. The Framework Directive 1999/2/EC of the European Parliament and Council covers general and technical aspects for carrying out the process, labelling of irradiated foods and conditions for authorising food irradiation.

The Implementing Directive 1999/3/EC provides a list of foods and food ingredients that are authorised across the EU for irradiation. Currently only dried aromatic herbs, spices and vegetable seasonings are listed. That said, MS may continue to irradiate foods that have already received national authorisations prior to the implementation of the directive. MS may also retain existing restrictions or bans on irradiated foods not listed in the Directive.

Regulation of food irradiation in ROI is shared by three Government bodies: the FSAI, the Department of Health and Children and the Radiological Protection Institute of Ireland. In NI, the FSA is responsible for the regulation of food irradiation.

3.3.4 Unintentional contamination

3.3.4.1 Mycotoxins

Mycotoxins are chemical compounds produced by moulds including those that colonise crops while in the field or post harvest. As a result, they can enter the food chain and represent a significant health concern for both humans and farm animals.

Mycotoxins have a wide range of toxic effects including carcinogenicity, genotoxicity and target organ toxicity.

Although any food susceptible to fungal contamination can, in theory, be a source of mycotoxins, the principal food commodities affected are cereals, nuts, dried fruit, coffee, cocoa, spices, oil seeds, dried peas, dried beans, and fruit, particularly apples and grapes.

Mycotoxin control is not as significant a problem in the production of fruit and vegetables as it is in cereal production. Those mycotoxins for which maximum levels have been established in certain food commodities, such as the aflatoxins and ochratoxin A, are not associated with fruit and vegetable production. However, certain trichothecene mycotoxins, zearalenone, citrinin and patulin have been detected on particular fruit or vegetable varieties.

Of these, the most significant is the occurrence of patulin in apples and apple-derived products. Within the EU, Commission Regulations 1425 of 2003 and 455 of 2004 establish maximum levels for patulin in apples and apple-derived products, including cider and juice as well as in fruit juices in general. Commission Recommendation 598 of 2003 provides guidance on the prevention and reduction of patulin contamination.

3.4 Third Country Import Controls

Imports of plants and plant products from Third Countries are covered primarily by the general food hygiene legislation or 'Hygiene Package' and other specific plant health legislation (Directive 2000/29/EC).

Unlike the requirements for Third Countries involved in the export of food of animal origin, those Third Countries involved in the export of food of non-animal origin do not have to appear on a list of exporters approved to export to the EU (normally held by the competent authority in cases of food of animal origin). In many cases, it is sufficient that exporting establishments in Third Countries are known to and accepted as suppliers by importers of food into the EU. For consignments containing plant or plant products which are covered by EU plant health legislation (listed in part B of Annex V to Directive 2000/29/EC), the exporter must obtain a phytosanitary certificate issued by the competent authority of the exporting country (European Commission 2006a). This normally involves registration. These measures exist to prevent the introduction of serious diseases and pests of plants and plant products into and within the EU.

The phytosanitary certificate certifies that the plants and/or plant products:

- Have been subject to the appropriate inspections;
- Are considered to be free from quarantine harmful organisms, and practically free from other harmful organisms; and
- Are considered to conform with the phytosanitary regulations of the importing country (European Commission 2006b).

Under Regulation (EC) No 882/2004 (part of the Hygiene Package), the Commission can request Third Countries to provide accurate and up-to-date information on their sanitary and phytosanitary regulations, control procedures and risk assessment procedures with regard to products exported to the EU.

DAF is responsible for the checks described in Section 3.4.2 on plants or plant products that are covered by Annex V to Council Directive 2000/29/EC. DAF is also responsible for checking in accordance with Commission Regulation (EC) No 1148/2001 that imported fresh fruit and vegetables conform to EU marketing standards. The function of the EU marketing standards regulations is to ensure that produce offered to the consumer is sound, clean and of marketable quality and that it is accurately labelled with information regarding the origin, quality class and packer and dispatcher information. (Department of Agriculture and Food 2006a)

DARD carries out Plant Health Third Country import inspections on horticultural produce to try to prevent the introduction of pests and diseases from being brought into NI. Again on the horticultural marketing front, imports of fruit and vegetables are inspected to ensure that they conform to EU standards (Gamble 2006).

3.4.1 European Commission, Food and Veterinary Office

The function of the FVO is to ensure effective control systems through the evaluation of compliance with the requirements of EU food safety/quality, veterinary and plant health legislation, both within the EU and in Third Countries exporting to the EU. The FVO does this mainly by carrying out inspections in MS and in Third Countries exporting to the EU.

Each year the FVO develops an inspection programme, identifying priority areas and countries for inspection. In order to ensure that the programme remains up to date and relevant, it is reviewed mid-year. The FVO makes recommendations to the country's competent authority to deal with any shortcomings revealed during the inspections. Following an inspection, the competent authority can be requested to present an action plan to the FVO on how it intends to address any shortcomings. Together with other Commission services, the FVO evaluates this action plan and monitors its implementation through a number of follow-up activities.

The Central Competent Authority in NI is the FSA who is responsible for implementing the public health requirements and also DEFRA which is responsible for implementing plant health requirements. Local authorities, through Environmental Health Officers (EHOs), are responsible from farm gate through to the retail and catering stages of the food chain. In ROI, the Central Competent Authority is the FSAI. DAF is responsible for the control of all fruit and vegetable products from production up to the point of retail, while the Health Service Executive (HSE), through EHOs, is responsible from farm gate through to the retail and catering stages of the food chain. DAF and the HSE exercise their functions through service contracts with the FSAI.

In its role, the FVO, where appropriate, may highlight areas where the Commission may need to consider clarifying or amending legislation or areas where new legislation might be required. In addition, the FVO produces other reports, such as summaries of the results of inspections or the annual EU-wide pesticide residues monitoring reports. The FVO also publishes an annual report on its activities, which reviews the progress of its inspection programme and presents the global results.

3.4.2 Border Inspection Posts

Imports of plants and plant products from Third Countries must come through designated Border Inspection Posts (BIPs) and be subjected to a series of checks before they are allowed access to the EU market. Third Country import controls can be undertaken in any one MS before the product is allowed to circulate freely in other MS, which effectively means that each MS is dependent on every other state to ensure that imports are controlled. It should

be noted that the BIP is not always in the country of final destination of the product. The BIPs are situated in strategic locations in each MS and are under the supervision of the relevant competent authority of the MS. The FVO routinely audits the controls carried out in these BIPs.

The list of BIPs operating within the EU is drawn up in Commission Decision 2001/881/EC, as amended. There are currently five BIPs on IOI, namely Dublin Airport, Dublin Port, Shannon Airport, Belfast International Airport and Belfast Port.

Council Directive 2000/29/EC contains provisions concerning the compulsory plant health checks to be carried out on certain plants and plant products coming from Third Countries. These checks consist of documentary, identity and physical plant health checks with a view to ensuring compliance with the European Commission's general and specific import requirements. Documentary checks consist of verification of the certificates and documents that accompany a consignment and in particular the phytosanitary certificate. Identity checks consist of verification that the consignment corresponds to the plants or plant products detailed in the certificate. Plant health checks consist of verification, on the basis of an inspection of a part of or the entire consignment, that it is free from harmful organisms. Commission Regulation EC/1756/2004 provides for plant health checks at a reduced frequency where this can be justified.

Plants or plant products failing to comply with the control checks may be detained for further examination, returned to the exporting country or destroyed. All rejections are notified to the EU Commission and if there is a public health risk, this is communicated to all MS via the Rapid Alert System for Food and Feed (RASFF). Once the shipment has met the required conditions it is released for free circulation within the EU. Copies of the health certificate and the BIP clearance document must accompany the consignment to its destination.

The Competent Authority in the MS carries out initial monitoring of controls at BIPs. In the case of ROI, this is done by the DAF on behalf of the FSAI and in NI by DARD. The FVO is required to inspect BIPs; the frequency and scope of which is defined based on risk analysis, as outlined by Commission Decision 2005/13/EC. Where the operation or the facilities for checking product at a BIP is considered inadequate, approval of the BIP may be withdrawn.

3.5 Product Traceability and Recall

In recent years there have been a series of high profile food scares, which have focussed attention on how the supply chain operates, from production through processing, and finally distribution. Such 'scares' have the potential to seriously damage consumer confidence in the food chain, whether they present real or perceived food safety risks. They have also highlighted serious deficiencies in traceability systems and also in European Law. This resulted in the formulation and adoption of EU Commission Regulation (EC) No. 178/2002 which lays down the general EU principles and requirements of food law including traceability and recall requirements. This regulation was implemented as of 1 January 2005.

3.5.1 Product Traceability

In today's global food market, effective traceability and product recall systems are paramount, even in the best-managed food business where an issue involving the safety of a foodstuff may occur.

Article 18 of regulation No. 178/2002 requires that traceability of 'food, feed, food producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.'

In the event of a foodborne hazard being identified in a particular batch of fruit or vegetables, or a case of foodborne illness associated with consumption of fresh produce having been reported, a full traceability system will permit identification of where the produce originated; the raw materials involved in its production; who handled the produce since it was produced; how it has been stored during transit; and the final destination of the produce. This information will enable a rapid and targeted recall of potentially hazardous product, thereby

preventing any further food safety problems.

There is no SI in ROI for non-animal origin products, so no prosecution can be taken yet under EC Directive 178/2002 and no offence has been created for non-compliance.

3.5.2 Product Recall

The objective of a product recall is to protect public health by informing consumers of the presence on the market of a potentially hazardous foodstuff and by facilitating the efficient, rapid identification and removal of the unsafe foodstuff from the distribution chain. There are two levels of product recall:

1. Recall – the removal of unsafe food from the distribution chain extending to food sold to the consumer, and
2. Withdrawal – the removal of an unsafe food from the distribution chain not extending to food sold to the consumer.

Regulation (EC) No. 178/2002, in addition to laying down the requirements for product traceability and recall, also established RASFF which is a notification system operated by the European Commission to exchange information on identified hazards between MS. In each MS there must be a single liaison contact point to deal with alerts arising within that State, or issued by RASFF. The FSA NI and the FSAI in ROI are the primary contact points on IOI. Notifications of alerts are issued by the single liaison contact point within each MS to official agencies and food businesses relating to an identified hazard and are classified as either one of two categories, “For Action” or “For Information”. Action is required when there is an identified direct or indirect risk to consumers. Information alerts do not require action, but relate information concerning a food or feed product that is unlikely to pose a risk to health, e.g. inform relevant authorities of consignments blocked at border inspection posts.

The FSAI has issued a Guidance Note (FSAI 2002) relating to Product Recall and Traceability (applicable only to food) and also a Code of Practice on Food Incidents and Food Alerts (FSAI 2004). A similar guidance document has been issued by FSA NI, Guidance Note on EC Directive 178/2002 (FSA NI 2004), and includes guidance on product recall and traceability.

In ROI, a “National Crisis Management Plan” was developed by the FSAI in conjunction with all of the official agencies so that a structured, coordinated and efficient response to any food safety crisis can be employed where the event arises. The FSA has set up an Incidents Taskforce to strengthen existing controls in the food chain so that the possibility of future food incidents occurring may be reduced. It also aims to improve the management of such incidents when they do occur (FSA 2006).

3.5.2.1 RASFF Notifications

Fruit and vegetables accounted for 242 notifications to the European Commission in 2004. This represented seven percent of alert notifications (49) and ten percent of information notifications (193). Examples of notifications included sulphites in dried apricots, ochratoxin A in dried figs, *C. jejuni* in rucola lettuce, aflatoxins in dried figs and *S. Typhimurium* in rucola lettuce (European Commission 2004).

There were no FSAI or FSA alerts (for action or information) relating to fresh fruit and vegetables in 2005.

4. Nutrition

4.1 Introduction

The nutritional value of fruit and vegetables is reflected in the fact that these plant-based foods represent one of the five major food groups in dietary guidelines. International recommendations by the WHO advocates a daily intake of at least 400g of fruit and vegetables for health (WHO 2003).

Fruit and vegetables are described as 'low energy-dense foods relatively rich in vitamins, minerals and other bioactive compounds as well as being a good source of fibre' (WCRF and the AICR 1997). There are a number of plant-based foods which are strictly classified as fruit and vegetables or are produced from fruit and vegetables but are considered otherwise from a nutritional perspective. These include tubers such as potatoes that are classified into the 'Breads, Cereals and Potatoes' food group due to their high starch content. Additionally foods such as jams and jellies derived from fruit and vegetables are classified as foods high in sugar due to fact that they lose much of their original nutritional value during processing. Herbs are generally also not classified as fruit and vegetables due to fact that they are consumed in small amounts. Fruit juices made from fruit or fruit concentrate are also classified as fruit.

4.2 Nutritional Composition of Fruit and Vegetables

Different types of raw fruit and vegetables have differing nutrient compositions and are thus classified to reflect this (Appendix D). In general, fruit and vegetables are good sources of non-starch polysaccharides (NSP)/fibre, carotenoids, vitamin C, folate, potassium and other vitamins, minerals and bioactive compounds. The low energy density of fruit and vegetables is attributable to their generally high water content.

Raw fruit and vegetables are low in energy and fat. The exception to this rule is avocados which contain more fat than most fruit and vegetables. However, avocados are rich in monounsaturated fats and vitamins and minerals including vitamin E, potassium and vitamin B₆. If consumed frequently, smaller portions of this fruit are advised. The carbohydrate content of fruit and vegetables can be attributed to starch, sugar and fibre. Vegetables in general contain both starch and sugar whereas fruit generally contain mostly sugar. The sugar present in fruit and vegetables is mainly in the form of fructose. This sugar is classified as 'intrinsic' sugar in contrast to 'added' or 'extrinsic' sugars, the latter of which should be limited in the diet (WHO 2003).

Fruit and vegetables contain moderate to rich amounts of NSP. NSP is a major component of plant cell walls and the term most commonly used among nutrition professionals to describe dietary fibre intake⁵. NSP is characterised as insoluble and soluble depending on its physiological effects. Soluble fibre blocks glucose and lipid absorption whereas insoluble fibre contributes to faecal weight and reduces intestinal transit time. The NSP found in fruit and vegetables in general contains higher concentrations of insoluble fibre.

Fruit and vegetables generally contain very small amounts of protein with beans and legume seeds being the exception. These have a protein of higher quality in comparison to other fruit and vegetables and offer a good source of protein for vegetarians.

Vitamin C is the micronutrient found in highest concentrations in fruit and vegetables. The vitamin C content of fruit and vegetables varies, with citrus fruits having some of the highest levels. However, different types of fruit and vegetables contain a range of vitamins, minerals and trace elements (see Appendix E).

Raw fruit and vegetables are a low energy dense food source in the diet that offers a diverse range of micro-

⁵ There are two different methods used to measure fibre in foods – the englyst method which is used in the UK and the AOAC (Association of Official Analytical Chemists) method which is used internationally. The englyst method measures NSP only, while the AOAC method measures NSP and other components such as lignin and waxes.

nutrients. Dietary guidelines recommend 'variety' in the consumption of fruit and vegetables due to fact that different types of fruit and vegetables contain different nutrients.

In addition to nutrients, which have a defined metabolic role in humans, fruit and vegetables contain a wide variety of compounds known as phytochemicals. These compounds have the potential to exert a physiological effect and there is a growing body evidence to suggest that these compounds may play a protective role against chronic disease. Hundreds of these compounds have been identified in fruits and vegetables and include:

- Organosulphur compounds in onion, garlic, leeks, chives, cabbage, cauliflower, broccoli and brussels sprouts;
- Terpenes in citrus fruits;
- Flavanoids and other phenolic compounds in most fruits and vegetables;
- Plant sterols in most vegetables;
- Phytoestrogens in soyabean, seeds, fruits and berries.

4.3 Effects of Processing and Cooking on Nutritional Composition

Without intervention, the ripening and spoilage of fruit and vegetables occurs naturally but will occur at a rate that will be dependant on air temperature and other environmental factors such as exposure to microorganisms.

From a nutritional perspective, the spoilage process involves enzymatic activity which utilise many micronutrients, in particular antioxidant nutrients such as vitamins A, C and E and selenium. In addition, alterations in the macro-nutrient content can also occur. For example, as bananas ripen and the spoilage process begins the predominant form of carbohydrate in the unripe fruit, ie. starch, is slowly converted into sugar.

The skin of whole fruit and vegetables offers a degree of protection from the environment. Once the skin is broken the fruit or vegetable is exposed to more oxygen which initiates enzymatic activity and utilisation of micronutrients. For this reason it is recommended that fruits and vegetables are peeled or chopped as close as possible to the time of consumption.

The following section outlines the effect of different storage, preparation and cooking techniques on the nutritional content of fruit and vegetables.

4.3.1 Preservation methods

Preservation methods used for fruit and vegetables aim to slow down or inactivate the spoilage process. The most common methods used are cold storage, canning and drying. Each method has an effect on the nutritional content of fruit and vegetables and is described below.

4.3.1.1 Cold Storage – refrigeration and freezing

Refrigeration and freezing are practical methods for prolonging the shelf-life of many fruit and vegetables. Refrigeration at temperatures of 3 to 5°C reduces the level of enzyme activity in the fruit and vegetables, thus reducing the metabolism of nutrients. Studies have shown that fruit and vegetables stored at room temperature lose vitamins much more rapidly compared to refrigeration and freezing. For example, spinach stored at room temperature (20°C) lost 27 percent of its folate over a ten-hour period compared to a 26 percent loss over seven days when stored at 4°C (Pandurangi and LaBorde 2004). Nevertheless, not all fruit and vegetables are suited to refrigeration such as unripe bananas. These should not be stored in a refrigerator as this interrupts the ripening cycle and thus should be left at room temperature. Once ripened, bananas may be stored in a refrigerator for up to two weeks.

Deep-freezing at temperatures of around minus 18 to minus 20°C extends the life of many fruit and vegetables for long periods provided the food is well covered to prevent water loss due to sublimation. At these low temperatures enzymatic activity does not occur and if the fruit and vegetables are frozen within hours of harvest there is little effect on their overall nutritional composition.

It is common practice in industry to steam or blanch vegetables to inactivate enzymes prior to freezing and the addition of heat and excess water can result in the loss of some vitamins. Nevertheless, many frozen fruit and vegetables maintain higher vitamin contents compared to their fresh counterparts stored at room temperature or refrigeration. Some fruit may, however, have a softer texture on thawing.

4.3.1.2 *Drying*

Drying involves the removal of moisture from the cells and tissues of the food through the application of heat so that bacteria, yeasts and moulds cannot grow and cause spoilage. This treatment has a large impact on the nutritional composition of fruit and vegetables primarily as a result of concentration of nutrients (such as energy and carbohydrate) as a result of water loss and the application of heat which denatures heat sensitive nutrients. For example, dried prunes contain 160kcal/100g, whereas raw plums contain 36kcal/100g (Food Standards Agency 2002). A small amount of starch can also be rendered resistant due to the application of heat.

Drying can also cause a loss of vitamin C and folate as these nutrients are readily oxidised when heated, therefore levels are greatly reduced in dried fruit and vegetables.

Fruit and vegetables may be pre-treated before drying. These treatments include immersion in a salt solution, ascorbic acid solution or steam blanching. This pre-treatment is usually carried out on light coloured fruit and vegetables, such as apples, peaches and pears as it prevents them darkening during drying and storage. It is therefore important to read the labels on dried fruit and vegetable packaging in order to determine if additional nutrients such as salt have been added.

4.3.1.3 *Canning*

The canning process involves placing foods in sealed containers and heating them to a temperature that destroys food spoilage bacteria. The sealed container further protects against oxidative changes.

Canning can result in the loss of micronutrients, particularly vitamin C and folate, with greater losses in some fruit and vegetables than others. For example, brussel sprouts can lose up to 97µg/100g vitamin C and all of their folate (135µg/100g) during canning. Similarly, canned peas have little vitamin C and less than half the folate content of fresh peas (FSA 2002). Nevertheless, many nutrients are retained during canning and it is a very practical method of preservation. Canning will however, increase the level of sodium in vegetables if the vegetables are stored in brine (salt solution). For example, canning of spinach in brine is reported to increase the sodium content by 0.6g/100g (FSA 2002).

Similarly for fruit the medium that it is stored in will influence the nutritional content of the fruit to varying degrees. Canned fruit in syrup is significantly higher in energy and sugar compared to canned fruit in juice. The fibre content of vegetables is also decreased when canned, for example canned tomatoes have 0.5g less fibre per 100g than raw tomatoes (FSA 2002).

4.3.1.4 *Pickling*

When compared to the raw form, pickled vegetables are lower in the macronutrients, energy, protein and carbohydrate. They are also lower in fibre content (pickled beetroot reduced by 0.3g/100g compared to raw beetroot).

Pickling significantly increases the sodium content of vegetables due to the use of salt in the process. For example, a 60g portion of pickled onions contains 0.25g more sodium than 60g of raw onions (FSA 2002).

With regard to the other micronutrients, pickling results in a small reduction in the levels of iron, calcium and vitamin C, with folate content being most affected (100g of raw beetroot contains 150mg of folate, compared to pickled beetroot which contains 2mg/100g) (FSA 2002).

4.3.1.5 Irradiation

The effect of irradiation on the nutritional quality of food is similar to, and in some cases less than that of other preservation methods. Only minor changes are observed in the level of some vitamins (B₁, C, A and E), while carbohydrates, fats and proteins remain largely unaffected by low or medium doses. However, nutritional changes in food due to irradiation are dependant on factors such as the temperature, radiation dose, packaging environment and storage conditions. Irradiation of frozen food or of food in an oxygen-free environment has been shown to minimise nutrient loss (FSA 2002). Refer back to Section 3.3.3.9 (p.49) for further information on food irradiation.

4.3.2 Preparation Methods

4.3.2.1 Juicing

‘Fruit juice’ is the extracted juice of fruit, which has not been concentrated and will have a shelf-life of “days”. ‘Fruit juice from concentrate’ is juice, which has been concentrated and returned to its original state by the addition of water. It will have a longer shelf-life than ‘fruit juice’ (FSAI 2004).

A glass of fruit juice only provides one portion of the recommended Five-a-Day, irrelevant of how much is taken as it does not have the same nutritional benefits as whole fruit. When compared to a raw eating apple, unsweetened concentrated apple juice can be significantly higher in energy and sugar. This is due to the fact that up to 15g of sugar (4 kcal/g sugar) per litre may be added to the concentrated juice to regulate acidic taste. This must be indicated in the ingredients but the juice may still not have the label “sweetened”.

During processing the outer layer of the apple, which is high in soluble fibre, is removed. There is also some loss of fibre during the extracting process which can further reduce the fibre content of the juice.

The biggest nutritional difference between fruit juice and concentrated fruit juice is the vitamin C content due to its loss during processing. However, any vitamin C lost is generally replaced by the processor giving an increased level compared to the raw fruit. Fruit juice may also be fortified with calcium and iron.

Vegetable juices are less commonly consumed than fruit juices but are growing in popularity. The impact of juicing vegetables is similar to that of fruit.

4.3.2.2 Peeling and Chopping

Peeling fruit and vegetables results in a small decrease in the fibre content as the skins of fruit and vegetables are high in fibre. An example of this is a medium-sized apple, when peeled loses 0.2g of fibre.

It is advisable to cook or consume fruit and vegetables as soon as possible after chopping or preparing them. If left at room temperature chopped fruit and vegetables are more susceptible to oxidation which results in loss of nutritional value as discussed earlier in this chapter.

Storing chopped fruit and vegetables in water for long periods of time can result in the leaching of nutrients into the water, in particular water soluble vitamins, such as vitamin C.

4.3.2.3 Mashing and smoothies

Mashing or making fruit and vegetables smoothies is similar to juicing; however, they have greater benefits as the nutritional composition of the mashed fruit and vegetables is closer to that of the raw fruit as the pulp is not removed. Smoothies and fruit juices made from fresh fruit as opposed to fruit concentrate have a more favourable nutrition profile. Fruit concentrates will have a higher sugar content.

4.3.2.4 Other preparation methods

The addition of salt, sugar and fat during preservation and cooking can dramatically alter the nutrient content of the food consumed.

Fruit and vegetables in the supermarket and catering establishments are prepared in many different ways. For example many salads are prepared with a dressing added. The typical energy and fat content of a portion (15g) of French dressing and a Caesar dressing are 82kcal and 8g of fat and 79kcal and 9g fat (FSA 2002), respectively. By asking for or preparing a dressing on the side and reducing the actual amount of dressing added, considerable less energy and fat can be consumed.

Vegetables are also often prepared with a sauce. For example a portion of boiled cauliflower contains 17kcal and 0.5g of fat compared to a portion of cauliflower in cheese sauce which contains 95kcal and 6g fat. In addition some fruit and vegetables are manufactured with a coating of oil, breadcrumbs or batter. These products are much higher in energy, fat and sodium than less processed varieties. An example of this is garlic mushrooms, which contain 61 kcal and 6 g fat per portion, compared to portion of boiled mushrooms which contain 5 kcal and 0.1g fat.

4.3.2.5 Packaging

Consumer demand for fresh, naturally preserved food products has grown dramatically in recent years and as a result many fruit and vegetables are packaged in order to preserve them. As discussed in Section 3.2.3.3, the most common type of packaging used is MAP with CAP being utilised to a lesser extent.

When compared with storage in air MAP has been shown to have a positive effect on retaining the nutritional content of fruit and vegetables (Artes-Hernandez, Aguayo et al. 2004; Cocci, Rocculi et al. 2006). Other studies, however, have indicated a detrimental effect on the vitamin C content of fruit and vegetables (Artes-Hernandez, Aguayo et al. 2004; Cocci, Rocculi et al. 2006). In the latter studies, however, a controlled sample stored in air was not included to provide a valid comparison.

4.3.3 Cooking methods

There are a variety of cooking methods used today and all can affect the nutritional content of fruit and vegetables. Cooking is a necessary part of making many vegetables more edible, with the application of heat breaking down the starch. However, it should be noted that some starch is rendered resistant to absorption resulting in a small increase in fibre.

4.3.3.1 Boiling, steaming and microwaving

Boiling is the traditional method of cooking vegetables. Although boiling has little impact on the macronutrient content of vegetables it can have a large impact on micronutrients.

The vitamin C, calcium and folate content of most vegetables are reduced significantly when boiled. This is primarily due to vitamins and minerals leaching into the cooking water. Vitamin and mineral loss can be reduced by boiling vegetables in as little water as possible or using alternative methods such as steaming or microwaving. To preserve some of the nutrients if boiling is the preferred method, the cooking water could be used to make sauces, soups or gravy.

The fibre content of the vegetables remains similar when boiled. Boiling in salted water retains the same level of nutrients as boiling in unsalted water, with the exception of sodium. Sodium levels of vegetables boiled in salted water can increase by up to 0.1g/100g.

Traditionally baking soda is added to green vegetables to retain the colour. However, bicarbonate of soda not only increases the sodium content of the vegetables but also destroys vitamin C.

4.3.3.2 Stewing

Stewing is a traditional way on cooking many fruit. When stewing without sugar, there is very little change to the nutritional composition of the fruit. One exception is the significant reduction in the fibre content. Stewing facilitates the process of hydrolysis, which breaks down the fibre causing a loss in the final product.

For small fruit such as blackberries, raspberries and red currants there is a greater reduction in the vitamin C levels during stewing than for larger fruits such as pears, plums and rhubarb. For example, stewed raspberries lose 14mg

of vitamin C per 100g compared to the loss of 1mg of vitamin C in 100g stewed rhubarb (FSA 2002). The addition of sugar will increase the final sugar content of the fruit consumed.

4.3.3.3 Other

Grilling, frying and baking are methods used frequently in the cooking of fruit and vegetables. The biggest impact these methods have on the nutritional value of the fruit or vegetable will depend on the addition of oil or other cooking fats. For example fried onions contain over 10g more fat than baked or raw onions (per 100g; average portion is 60g) (FSA 2002). Also grilling instead of frying tomatoes can reduce the fat content by more than 6g (per 100g; average portion is 34g).

4.3.3.4 Overcooking

Overcooking fruit and vegetables will also result in a change in the nutritional content of the food. There will be a greater loss in nutrients such as vitamin C which are unstable to heat, due to overcooking.

4.3.3.5 Functional Food Products

The functional food market has grown internationally and has expanded into the area of fruit and vegetables. Such products tend to be smoothie-like products which have nutrients such as fibre and vitamins added to reflect the original product although this will not be to the original levels found in the raw product. Whether these products have the same effect in the long term as consuming fruit and vegetables is as yet unknown.

4.4 Dietary Composition Patterns

4.4.1 Current Consumption of Fruit and Vegetables on IOI

4.4.1.1 Adults

The most detailed study of fruit and vegetable intake among adults in IOI was the North South Ireland Food Consumption Survey (NSIFCS) carried out from 1997 to 2000 (Irish Universities Nutrition Alliance 2001).

The mean intake of fruit and vegetables among adults aged 18 to 64 years on the IOI was found to be 136g/d and 140g/d, respectively (O'Brien, Kiely et al. 2003). This is approximately equivalent to 3.5 portions of fruit and vegetables per day. A breakdown of fruit and vegetable intakes among the adults surveyed is given in Appendices E and F.

Tomatoes⁶ and carrots were the vegetables consumed in the highest quantities with apples, bananas and orange juice being the most popular fruit consumed.

Composite foods ie. foods that contain a mixture of ingredients, contributed a mean of 37g vegetables and 6g fruit per day among adults. This vegetable intake represents 26 percent of total vegetable consumption. Carrots, tomatoes and other vegetables, e.g. mushrooms, onions and peppers were the vegetables consumed in the highest quantities in composite meals. Composite meals contributed less to total fruit intake at five percent of total fruit intake.

The analysis carried out on the NSIFCS highlights the importance of composite foods to the intake of fruit and vegetables by the population on IOI.

Age had a significant effect on the consumption of fruit and vegetables. The younger age group (18 to 45 years) had a significantly lower intake ($p < 0.01$) of vegetables and fruit compared with the older group (51 to 64 years) (for vegetable intake this was a mean of 128g/d and 147g/d, respectively; and for fruit 114g/d and 156g/d, respectively). Younger males were less likely to eat green vegetables and cauliflower and more baked beans than older male age groups. Fruit intake increased with age among women.

When adjusted for energy intake, fruit and vegetable consumption was higher ($p < 0.01$) among women than men. Men consumed less salad vegetables, broccoli, peppers and tomatoes and more baked beans.

⁶ Tomatoes are ordinarily classified as a fruit. In the IUNA study, however, they were classified as a vegetable as this was what consumers perceived them as being.

Based on the data from the NSIFCS, approximately 21 percent of men and 19 percent of women are meeting the current international and national recommendations of $\geq 400\text{g/d}$. When considering the USDA's separate recommendations for fruit and vegetables (at least two portions of fruit and three portions of vegetables), both men and women are more likely to achieve the fruit recommendations than vegetable recommendations. The percentage of individuals achieving the dietary recommendations for fruit and vegetables was found to increase with increasing social class and increasing level of education. Current smokers as a group were found to have the lowest number of compliers.

The Survey of Lifestyle Attitudes and Nutrition study of adults in ROI described 70 percent of females and 68 percent of males reporting eating four or more portions of fruit and vegetables per day (Health Promotion Unit 2003). This study used a food frequency method which is known to over-report consumption of food when compared to the seven day diary method used in NSIFCS (Bingham, Gill et al. 1994). This in part explains the high compliance noted in SLÁN. The daily recommended intake for fruit and vegetables has since increased in ROI from four to five portions per day. SLÁN also reported a social class and age effect on fruit and vegetable consumption.

4.4.1.2 Children and Adolescents

Preliminary analysis of the National Children's Survey of five to twelve year olds in ROI has indicated a low intake of fruit and vegetables among this age group (Irish Universities Nutrition Alliance 2006). The intake of different types of fruit and vegetables is given in Appendix H.

The average intake of vegetables in this population is equivalent to a little more than half a portion per day. Fruit intake is nearly equivalent to two portions per day but more than half of this fruit intake is made up of fruit juice. However, it should be noted that this preliminary analysis of the data does not include fruit and vegetable intake from composite foods and is likely to underestimate the true intake among the group. **safefood** and the HSE are funding further analysis of this data.

In the *Health Behaviour of School Children* survey a low consumption of fruit and vegetables was reported among 10 to 17 year olds in ROI with 15 percent of girls and 16 percent of boys reporting never eating fruit or eating it less than once a week. Twelve percent of girls and 14 percent of boys reported never eating vegetables or eating them less than once a week. Figures for those reporting to eat fruit or vegetables more than once daily were 20 percent or less. (Health Promotion Unit 2003)

In NI the *Young Hearts Study* of 1345 boys and girls aged between 12 and 15 years also investigated fruit and vegetable intakes using a seven day diary method (McGartland, Robson et al. 2004). Average fruit intakes for 12 year old boys, 12 year old girls, 15 year old boys and 15 year old girls were 143, 178, 144 and 163 g/d, respectively. Average vegetable intakes were 61, 55, 70 and 59 g/d respectively.

The *Eating for Health* Survey carried out by the Health Promotion Agency in 2001 reported that one in five boys and one in eight girls in NI aged five to 17 years did not eat any fruit and vegetables on a daily basis (Health Protection Agency 2001). This survey also demonstrated a lower consumption of fruit and vegetables among lower socio-economic groups.

4.5 Contribution of Fruit and Vegetables to Nutrient Intake

The NSIFCS quantified the contribution of fruit and vegetables (inclusive of composite foods) to nutrient intake of adults on IOI aged 18 to 64 years. (Irish Universities Nutrition Analysis 2001). These results are shown in Appendix J.

Vegetables contributed to less than three percent of energy; 17 percent dietary fibre (Southgate method); 63 percent carotene; 32 percent of total vitamin A; 13 percent vitamin E; 11 percent of folate; and 24 percent vitamin C intakes. Peas, beans and lentils were the main contributors to fibre intake while carrots were the main contributors to vitamin C. The other major contributors to vitamin C intake were those vegetables that were classified as 'other vegetables' which included mushrooms, peppers and onions.

Results indicated that fruit contributed to less than three percent of energy; 14 percent sugar; 25 percent vitamin C; and 11 percent copper intakes per day. Fruit and citrus juices were the main contributors to vitamin C intake from fruit. The preliminary results from the National Children's Survey have indicated that fruit and vegetables contribute small amounts to energy, fat, carbohydrate and protein levels (Irish Universities Nutrition Alliance 2006) (see Appendix I).

4.6 Patterns of Consumption

International studies evaluating dietary patterns and their relationship to chronic disease have demonstrated that the achievement of fruit and vegetable recommendations is also clustered with other dietary recommendations such as high fibre; rich wholegrain; and fish intakes; and moderate meat intakes (Jacques and Tucker 2001).

In the US, epidemiologists have investigated dietary patterns and their association with chronic disease (Hu, Rimm et al. 2000; Quatromoni, Copenhafer et al. 2002; Millen, Quatromoni et al. 2005). In the analysis of the Health Professionals Follow-up Study, two clear dietary patterns emerge – the 'prudent diet' and 'western diet'.

Higher fruit and vegetable consumption is one of the characteristics of the 'prudent diet' along with higher intakes of fish, whole grains and poultry. The 'western diet' is associated with higher intakes of red meat, processed meat, refined grains, sweets and desserts. In analysis of the Framingham study, five dietary patterns emerged with foods such as fish being a component of the 'Healthy Eating' pattern (Quatromoni, Copenhafer et al. 2002; Millen, Quatromoni et al. 2005). Similar to the previous findings a high fruit and vegetable consumption was clustered with other positive dietary behaviours patterns.

5. Health Benefits

5.1 Introduction

The health benefits of fruit and vegetables are well recognised. A rich and varied consumption of fruit and vegetables is an internationally recognised key feature of dietary patterns associated with reduced risk of chronic disease (Huijbregts, Feskens et al. 1997; Hu, Rimm et al. 2000; Quatromoni, Copenhafer et al. 2002).

In 2001, the European Prospective Study of Cancer (EPIC) estimated that an increase in fruit and vegetables intake of just 50g/d has the potential of cutting the risk of premature death from any cause by 20 percent (Khaw, Bingham et al. 2001). The authors also estimated that consuming an extra two daily portions (160g) of fruit and vegetables could reduce the risk by as much as half.

As outlined in the previous chapter, fruit and vegetables are a rich source of many micro-nutrients, fibre and phytochemicals as well as being low in energy. It is these nutrients either alone or in combination with each other that contribute to the health protective effects of these foods.

5.2 Cardiovascular Disease

Cardiovascular disease (CVD), which includes heart disease and stroke, is one of the major contributors to lifestyle related (non-communicable) diseases worldwide (WHO 2003). CVD, as with other non communicable disease, develops over a long period of time with the major risk factors including overweight, high blood pressure, dyslipidaemia (abnormal blood lipid levels), diabetes and low cardio-respiratory fitness. These risk factors are driven in part by unhealthy lifestyle behaviours such as poor diet and inactivity. A number of features of a poor diet tend to occur simultaneously and include high intake of saturated fat, salt and refined carbohydrates, and a low intake of fruit and vegetables.

A low intake of fruit and vegetables has been shown to be independently associated with a increased risk of CVD in a number of prospective and ecological studies (Gillman, Cupples et al. 1995; Ness and Powles 1997; Joshipura, Ascherio et al. 1999; Liu, Manson et al. 2000; Joshipura, Hu et al. 2001; WHO 2003).

The effects of a diet rich in fruit and vegetables alone and in combination with a low fat diet were investigated in the Dietary Approaches to Stop Hypertension study (Appel, Moore et al. 1998; Moore, Vollmer et al. 1999). The most effective diet was the combination of low fat dairy products and fruit and vegetables. However, an increase in fruit and vegetables alone was shown to result in a small but significant reduction in blood pressure that could significantly impact on the public health risk of CVD at a population level.

In a further six-month randomised controlled trial, 690 healthy individuals were assigned either to a control group and advised to continue their dietary habits; or an intervention group where they were supported and encouraged to increase their intake of fruit and vegetables to five or more portions per day (John, Ziebland et al. 2002). In this study a significant reduction in blood pressure, in particular systolic blood pressure was evident among the intervention group. Also in this study, the mean increase in self-reported fruit and vegetable intake was 1.4 portions per day.

In a recent meta-analysis of eight studies involving 257,551 individuals, it was shown that the consumption of more than five portions of fruit and vegetables a day was associated with a 26 percent reduced risk of stroke (He, Nowson et al. 2006), while an 11 percent reduction in risk of stroke was found in those who consumed three to five portions per day.

These data provide strong support for increased consumption of fruit and vegetables beyond current intake for CVD prevention.

The main benefits of fruit and vegetables on CVD risk have been attributed to their content of fibre (NSP), micronutrients such as antioxidant vitamins (vitamins C and carotenoids), folate and phytochemicals (WHO 2003).

It is well established that dietary fibre reduces total and low density lipoproteins and indeed a diet high in dietary fibre has been shown to reduce coronary heart disease (WHO 2003).

A number of studies (Yusuf, Dagenais et al. 2000; Heart Protection Study Collaborative Group 2002) have evaluated the effect of supplemental forms of the antioxidants, vitamin C and carotenoids, and also vitamin E on CVD. There was no effect on cardiovascular events with these supplements alone, indicating that it may be these vitamins in combination with the other components of fruit and vegetables that confer the beneficial effects.

Fresh vegetables and some fruit are good sources of folate. Folate has been shown to reduce elevated levels of the cardiovascular risk factor homocysteine through diet and supplements (Rimm 1998). A meta-analysis of existing evidence concluded that a higher intake of folate (0.8mg folic acid) would reduce the risk of ischaemic heart disease by 16 percent and stroke by 24 percent (Wald, Law et al. 2002). While this intake would be unachievable through diet alone, the contribution of folate along with other cardio-protective nutrients in a fruit and vegetable rich diet will have a greater impact on health than folic acid supplements alone.

Another group of compounds called flavanoids, which belong to the group of phytochemicals, are found in fruit and vegetables. The WHO indicated that the evidence to date supports a negative association between flavanoids and CVD (WHO 2003).

Fruit and vegetables are naturally low in sodium and a rich source of potassium in the diet. In the case of stroke risk, sodium has a negative association while potassium has a positive effect on this CVD event. The fruit and vegetable contribution to the intake of these minerals is thought to be a major mechanism through which they can contribute to a lower risk of stroke.

Overweight and obesity are key risk factors for CVD. Fruit and vegetables are low energy (calories) dense and low fat foods and thus can play a crucial role in regulating calorie intake. Inclusion of five or more portions of fruit and vegetables a day can reduce the energy density of a diet without reducing bulk. This is particularly pertinent given the rapid rise in overweight and obesity worldwide (International Obesity Taskforce 2006).

5.3 Cancer

In 1997 the World Cancer Research Fund (WCRF) and the American Institute for Cancer Research (AICR) carried out a comprehensive review of the evidence for a role of diet in the prevention of cancer (WCRF and the AICR 1997). This report concluded that 'between 30 and 40 percent of all cases of cancer are preventable by feasible and appropriate diets and by physical activity and maintenance of appropriate body weight'. It also reported that a diet containing substantial and varied amounts of fruit and vegetables will prevent 20 percent or more of all cases of cancer.

In coming to this conclusion the report noted that the evidence for dietary protection against cancer was the strongest and most consistent for fruit and vegetables. Consumption of fruit and vegetables was 'probably or convincingly' associated with a decreased risk of cancer of the mouth and pharynx; larynx; oesophagus; lung; stomach; pancreas; colon; rectum; breast; and cervix.

In its 2003 review of the evidence for a role of diet in chronic disease, the WHO recommends a diet including at least 400g of fruit and vegetables as one of eight recommendations for reducing the risk of developing cancer (WHO 2003). The report concluded that there is 'probable evidence' for a decreased risk with fruit and vegetable intake for oral cavity; oesophagus; stomach; and colorectal cancers.

The association with fewer cancers than the WCRF/AICR report can be attributed to the fact that the data linking the other cancers to fruit and vegetable intake is not as consistent. The 'probable' rather than 'conclusive' evidence by the WHO arose due to the fact that all the data available was not supportive, but on balance the data suggests a protective effect of fruit and vegetables. Furthermore, given the fact that oral cavity, oesophagus, stomach and colorectal cancer contribute greatly to the cancer burden on IOI (Central Statistics Office 2004; Northern Ireland Statistics and Research Agency 2004) this evidence is sufficient to indicate that an increase in fruit and vegetables intakes will have a significant public health impact of the incidence of these cancers on the island.

The data that has emerged since the 2003 WHO report has not provided any clearer answers to the association between fruit and vegetable intake and various cancers (Potter 2005) and in fact some data have indicated no association (Hung, Josphipura et al. 2004). A number of explanations for the data inconsistencies have been put forward such as methodological issues; changes in population exposures over time; and the fact that cancer is a diverse range of diseases (Potter 2005). The link between cancer and fruit and vegetables still requires further investigation. The second expert report from the WCRF reviewing the evidence for a link between diet and cancers will be published in 2007.

The mechanisms through which fruit and vegetables may contribute to reduce cancer risk have not been fully established but are attributed to their micronutrient, fibre and phytochemical content (WCRF and the AICR 1997; WHO 2003)

Many studies have investigated individual components of fruit and vegetables as risk factors for certain cancers. Inadequate intakes of micronutrients due to low intakes of fruit and vegetables and high intakes of animal products is thought to account for 60 percent of cancers of the oral cavity, pharynx and oesophagus particularly in developing countries (IARC 1990; WCRF and the AICR 1997).

It has been suggested that vitamin C is one of the protective agents in fruit and vegetables in relation to stomach cancer (WHO 2003). Indeed, the EPIC study found that by increasing blood vitamin C levels by 20 µM/L the risk of premature death from any cause, including cancer, could be reduced by 20 percent (Khaw, Bingham et al. 2001). The increase in blood vitamin C reported in this study can be achieved by consuming the equivalent of 50g of fruit and vegetables per day. This roughly corresponds to eating half a portion of fruit a day.

In the EPIC study (Khaw, Bingham et al. 2001), the authors estimated that adding two more daily portions of fruit and vegetables could reduce the risk of premature death by as much as half. These findings hold regardless of age, blood pressure or smoking. Whether vitamin C is a marker of fruit and vegetable intake or a protective agent has yet to be confirmed. The intake of folate has also been negatively associated with colorectal cancer (WHO 2003), while dietary fibre intake has been associated with reduced cancer risk in particular with colorectal cancer.

5.4 Diabetes

Diabetes is the result of the lack of the hormone insulin which is responsible for regulating the circulating glucose in the blood and tissues. Type I diabetes is characterised by partial or total failure of the beta-cells in the pancreas to produce insulin and normally develops suddenly in children and young adults. The more common form of diabetes, type II, is characterised by insulin resistance resulting from production of insufficient or ineffective forms of insulin. The latter form is associated with obesity and poor lifestyle behaviours and develops slowly appearing more commonly in middle to later life. In more recent times type II diabetes has become more common and evident in younger people and children.

Type II diabetes can result in devastating health consequences. In addition to the micro-vascular complications such as retinopathy and nephropathy, the disease increases the risk of cardiovascular disease. Abnormal lipid levels and high blood pressure, two of the major risk factors for CVD, are associated with type II diabetes.

The nutritional management of both type I and type II diabetes involves a diet where the consumption of five or more portions of fruit and vegetables is fundamental (Thomas 2004). A diet containing 45 to 60 percent carbohydrate, mainly derived from complex, fibre rich foods with a low glycaemic index (ie. foods that contain carbohydrates which are released more slowly into the blood stream, which means that blood sugar levels stay steady) such as starchy cereal foods, fruits and vegetables, is recommended. This control of carbohydrate intake allows control of blood glucose levels. In addition to the management of blood glucose levels, abnormal lipid levels occur in diabetes. Soluble fibre has a small beneficial effect on blood lipid levels.

The WHO reviewed the evidence for a role of the diet in the development of type II diabetes (WHO 2003). It concluded that there is probable evidence that dietary fibre plays a protective role in the prevention of type II diabetes. The 'probable' rather than 'convincing' conclusion was drawn due to the lack of clarity of the different roles of soluble and insoluble fibre.

A consistent feature of the evidence that the WHO reviewed in respect of diabetes was that diets contained wholegrains in addition to fruit and vegetables. Consequently one of the key recommendations for diabetes prevention that the WHO makes is the achievement of dietary fibre (minimum of 20g/d) through consumption of wholegrains, fruits and vegetables. Fruit and vegetables are a major source of fibre in the diet on IOI (O'Brien, Kiely et al. 2003).

5.5 Osteoporosis

Osteoporosis is a disease of the skeleton where there is low bone mass and deterioration of the structure of the bone resulting in increased susceptibility to fracture. The condition often goes undiagnosed until later in life when a fracture occurs and results in reduced mobility and loss of independence. Osteoporosis is more common in women than men due to the accelerated bone loss that occurs around the menopause. It is estimated that globally one in three women and one in five men aged greater than 50 years will have osteoporosis in their lifetime (Melton, Chrischilles et al. 1992; Melton, Atkinson et al. 1998; Kanis, Johnell et al. 2000).

Bone is a very metabolically active organ and up until the time of attainment of peak bone mass in the third decade of life, the process of bone formation exceeds that of bone resorption (removal of calcium from bones). After this point the balance between these two processes switches in favour of bone resorption and results in bone loss. Strategies for osteoporosis prevention focus not only on decelerating bone loss in middle to later life but also on the attainment of as high a peak bone mass as possible. The majority of peak bone mass occurs in adolescence.

The association between fruit and vegetable consumption and markers of bone health was first identified in older populations (New, Bolton-Smith et al. 1997; Tucker, Hannan et al. 1999; Macdonald, New et al. 2004). More recent studies have shown a positive association between fruit and vegetable intake and the attainment of peak bone mass in children and young people (Jones, Riley et al. 2001; McGartland, Robson et al. 2004; Tyllavsky, Holliday et al. 2004; Vantanparast, Baxter-Jones et al. 2005).

The majority of this evidence has been generated from observational data which does not indicate a causal link between fruit and vegetable consumption and bone health. For this reason the WHO has concluded that there is 'possible evidence' that fruit and vegetable intake is a protective factor in osteoporosis (WHO 2003). However, when this report was published most of the evidence available was in older age groups and since then the evidence base has grown for younger people. In a recent study (Pyrnne, Mishra et al. 2006) evaluated the association between fruit and vegetable intake and bone mineral status and found a positive association in adolescent boys and girls and older women aged 60-83 years.

As the evidence for a beneficial effect of fruit and vegetable on bone health is growing, there is increased research interest in the mechanisms driving the association. One popular theory is that fruit and vegetables provide alkaline salts of potassium that balance the acidity of a westernised diet rich in protein (New, Bolton-Smith et al. 1997). It is known that bone has the potential to release potassium to balance circulating acidity and this theory proposes that fruit and vegetable derived potassium protects bone from losing its own store of the mineral.

Other protective mechanisms include the beneficial effects of key nutrients found in fruit and vegetables, including folate and vitamin K and non-nutrient compounds such as phytoestrogens and flavanoids. However, it is likely that the combined effect of all these factors plays a role in contributing to the beneficial effects of fruit and vegetables on bone health.

5.6 Overweight and obesity

Internationally overweight and obesity are becoming more prevalent (WHO 2003). This rise in prevalence is associated with increasing rates of the co-morbidities of obesity such as CVD, cancer and diabetes. There is convincing evidence that a high dietary intake of fibre (most specifically NSP) is a factor in protecting against weight gain and obesity as well as being an effective weight loss strategy (WHO 2003).

In addition to adding bulk to the diet, dietary fibre has a satiety effect. Furthermore, a high intake of energy dense micronutrient poor foods is a causative factor in overweight and obesity. Fruit and vegetables are rich sources of NSP and are energy dilute food sources.

On the basis of this evidence, the WHO and national and regional recommendations for the prevention of overweight and obesity include the promotion of fruit and vegetables among adults and children.

5.7 Perceptions and Barriers to Change

It is well recognised that there are many barriers to the consumption of five or more fruit and vegetables and they can be broadly categorised into:

- Access to and availability of good quality, affordable fruit and vegetables locally;
- Attitudes and awareness – awareness of the fruit and vegetable message and people’s knowledge; and attitudes, motivation and skills in buying, preparing and eating fruit and vegetables.

5.7.1 Access and Availability

Socio-demographic factors are well known to affect food choice. Lower socio-economic status and lower education level are associated with lower consumption of fruit and vegetables. Higher social classes and those with a higher educational status are in general more health conscious and better able to conceptualise the relationship between diet and health (Cox and Anderson 2004).

Disposable income and the amount of money available to spend on food, influences the consumption of fruit and vegetables. In the qualitative discussion groups conducted for this review, participants also identified cost as a barrier to consumption, in particular for those who did not purchase in large quantities. Cost has been identified in research studies as a barrier to fruit and vegetable consumption across different socio-economic groups (Hagdrup, Simoes et al. 1998). This is further compounded by the perceptions that fruit and vegetables are not “filling” and can have a lot of wastage, thus poorer households often opt for cheaper, energy dense foods that are perceived as being filling and not wasteful (Friel and Conlon 2004). The access and availability of good quality fruits and vegetables can be a key barrier to the consumption of fruits and vegetables (Friel and Conlon 2004). This can refer to access and availability in the home, in a catering facility or within local retail provision.

As well as income there are other key influences on the purchase and consumption of fruit and vegetables including area of residence; car ownership/public transport; and shopping and storage facilities. Barriers also

identified during the qualitative discussion groups included the perceived short shelf-life of certain fruit and vegetables, and also the quality (and ripeness) of produce was seen to be 'hit and miss' thus discouraging consumers from purchasing these items.

5.7.2 Attitudes and Behaviour

At an individual level food preferences play a major role in the consumption of fruit and vegetables. Exposure in early life can influence fruit and vegetable intakes. Repeated exposure to vegetable flavours through breast milk has been shown to increase acceptability of vegetables during childhood compared to formula-fed infants (Cox and Anderson 2004).

The influence of family on children's food choices is known to have a very powerful influence. Repeated exposure to a greater variety of foods with variable textures, flavours and taste during childhood leads to greater acceptability of foods including fruits and vegetables. The preliminary results from the National Children's Survey in ROI demonstrate that children with parents who show food neophobia, ie. are adverse to introducing new foods into their diet, also demonstrated food neophobia themselves (Irish Universities Nutrition Alliance 2006). In adolescents who are taking greater responsibility in food choices, peer pressure and social acceptability plays a greater role. Taste was also identified as a barrier to the consumption of certain fruit and vegetables in the qualitative discussion groups conducted for this review.

Skills and confidence in preparing and cooking fruits are frequently reported as factors affecting consumption, of which the perceived effort and time are most commonly cited (Hagdrup, Simoes et al. 1998; Maclellan, Gottschall-Pass et al. 2004). Findings from the qualitative discussion groups supported these factors, as the inconvenience associated with the preparation of a number of fruit and vegetables, including lettuce, potatoes, cabbage and spinach was cited as a barrier to consumption. Other barriers to consumption that emerged from the discussion groups included the feared presence of pesticides and other chemical sprays, and genetic modification.

A study of 1438 young adults aged 18 to 24 years in the US identified confidence in buying, preparing and eating fruit and vegetables among men as a key barrier (Horacek, White et al. 2000). Confidence and self-efficacy were also reported as a barrier to fruit and vegetable consumption in another large US study of adults (Van Duyn, Kristal et al. 2001). Lack of understanding of what constitutes a portion has been reported in the UK as a potential barrier to meeting the Five-a-Day recommendation (FSA 2003).

5.8 Initiatives to Increase Fruit and Vegetable Consumption on IOI

The promotion of a diet high in fruit and vegetables has been the corner stone of healthy eating campaigns on an international level as well as at national and local levels.

5.8.1 Northern Ireland

In the UK (including NI) the Five-a-Day campaign has been running for a number of years. This campaign which is run by the Department of Health has five strands which include:

- school fruit and vegetables scheme;
- local Five-a-Day initiatives;
- national/local partnerships;
- communications programmes (including the Five-a-Day logo); and
- collaboration with industry⁷.

5.8.2 Republic of Ireland

In ROI, the Health Promotion Unit within the Department of Health and Children, in conjunction with various partners, has also promoted increased consumption of fruit and vegetables during national healthy eating campaigns. In addition, Bord Bia is a state-sponsored body with primary responsibility for the market development, promotion and information services relating to the horticulture industry. Formerly this responsibility rested with Bord Glas which was integrated into Bord Bia in 2004.

⁷ www.5aday.nhs.uk

Food Dudes is a healthy eating programme run by Bord Bia aimed at increasing fruit and vegetable intake in disadvantaged school children. There are currently 45 primary schools in Ireland participating in the programme⁸. The Food Dudes (2006) campaign recently won a WHO Counteracting Obesity Award (WHO 2006). (Food Dudes, 2006)

⁸WHO (2006) award winners (online), www.euro.who.int/obesity/20061117-1 [11 December 2006]

6. General

6.1 Introduction

The following chapter covers other aspects of the food safety continuum, including labelling, quality assurance schemes, and training, which have not been discussed in earlier sections.

6.2 Labelling

Labelling allows consumers to make informed decisions about the food they eat and also builds confidence in products. The general labelling of fresh produce (and indeed all food products) is governed by Council Directive 2000/13/EC on the Labelling, Presentation and Advertising of Foodstuffs, and by Council Regulation (EC) No. 2200/1996 which lays down marketing standards for quality and labelling of fresh fruit and vegetables.

6.2.1 General Food Labelling Requirements

Council Directive 2000/13/EC sets out general provisions on the labelling of pre-packaged foodstuffs to be delivered to the ultimate consumer.

Directive 2000/13/EC is implemented in ROI by the European Communities (Labelling, Presentation and Advertising of Foodstuffs) Regulations 2002 (SI No. 483 of 2002) and in NI by the Food Labelling Regulations (NI) 1996 (SR NI 1996 No. 383), as amended. Enforcement of this legislation lies with the FSAI in ROI and the District Councils in NI.

Directive 2003/89/EEC, amending Directive 2000/13/EC, concerns the labelling of allergens in foodstuffs. This legislation requires food manufacturers to indicate the presence of potential allergens (from a list of 12 as laid down in the Directive) if they are used as ingredients in pre-packed foods, including alcoholic drinks, regardless of their quantity. Celery is currently one of the twelve specific allergens listed for inclusion on product labelling.

6.2.2 Specific Fruit and Vegetable Labelling Requirements

The marketing standards for quality and labelling of fruit and vegetables are laid down in Council Regulation (EC) No 2200/1996 (as amended) on the common organisation of the market in fruit and vegetables. This regulation applies to selected fresh fruit and vegetables as laid down in the Regulation (Table 6.1)

Table 6.1 Fresh fruit and vegetables subject to EC Marketing Standards

Fresh fruit	Apples (dessert and culinary), apricots, avocados, cherries, citrus fruit (clementines, lemons, mandarins, satsumas, oranges), table grapes, kiwis, peaches and nectarines, melons, pears, plums, strawberries, watermelons
Fresh vegetables	Artichokes, asparagus, aubergines, beans, brussels sprouts, cabbage, carrots, cauliflower, garlic, celery, courgettes, cucumbers, lettuce (curly and escarole chicory), leeks, peas (for shelling), spinach, sweet peppers, tomatoes, onions, witloof chicory

The marketing standards stipulate that produce of all quality classes (Class I, Class II, and Extra Class – the latter applies to selected products only) must be sound, clean and of marketable quality. The person selling or offering the produce for sale must ensure that the produce is placed in the correct quality class. It is their responsibility to re-grade or downgrade to a lower quality class any product, which may have deteriorated while in stock. If only a few items of produce from a batch have deteriorated, then the retailer may opt to remove the deteriorated items rather than downgrade the entire batch to a lower quality class (see Appendix J for further information). The standards also state that each container or display of produce is clearly marked with the correct information regarding quality class, origin and, in certain cases, variety (Figure 6.2).

Figure 6.2 Information required on the label

Packer and/or dispatcher identification
Nature of produce (if not visible)
Origin of produce
Commercial specifications – quality class, size (if applicable, weight or number of units)
Official control marking (optional)
Name of seller within the EU
Date of minimum durability
Packed in a modified atmosphere (if applicable)

This information is usually marked on the packages in which the fresh produce is supplied. Specific requirements are laid down for product which is sold (i) loose, (ii) in original packing, and (iii) in pre-packs.

6.2.2.1 Product sold loose

Products may be presented unpackaged (loose) provided that the retailer displays (at point of sale) a card showing prominently and legibly the information particulars specified in the quality standards relating to variety, origin of the product and class.

6.2.2.2 Products sold in original packing

All packages must be labelled with all of the information required. In the case of packer/dispatcher identification, it is permissible to use either the name or address of the packer and/or dispatcher; or an officially issued or accepted code representing the packer and/or dispatcher indicated in close connection with 'packer and/or dispatcher'.

6.2.2.3 Produce sold in pre-packs

All pre-packs must display all of the required information and also the net weight or number (if not clearly visible). The packer and/or dispatcher must be identified on the pre-pack using either the name and address of the packer and/or the dispatcher, or the name and address of a seller established within the Community indicated in close connection with the mention 'packed for'. An officially issued code representing the packers name and address must also be included.

The marketing standards do not apply to processed or prepared fresh produce. This legislation is given effect in ROI by the European Community (Fruit and Vegetables) Regulations 1997 (SI 122 of 1997) and in NI by the Food Labelling (Amendment) Regulations (NI) 1998 (as further amended).

Additional legislation pertaining to the marketing of fresh fruit and vegetables is outlined in Table 6.3.

Table 6.2 Other legislation pertaining to the marketing of fresh fruit and vegetables

Legislation	Concerning
Commission Regulation 1148/2001	On checks on conformity to the marketing standards applicable to fresh fruit and vegetables
Commission Regulation 1135/2001	Amending the provisions concerning sizing, presentation and labelling laid down in the marketing standards for certain fresh vegetables and amending Regulation (EC) No 659/97
Commission Regulation 48/2003	Laying down the rules applicable to mixes of different types of fresh fruit and vegetables in the same sales package
Commission Regulation 907/2004	Amending the marketing standards applicable for fresh fruit and vegetables with regard to presentation and labelling

6.2.3 Nutrition Labelling

The nutrition labelling of foodstuffs is governed by Council Directive 90/496/EEC, as amended. This piece of legislation states that nutrition labelling is compulsory when a health claim is made. In this instance, and in other instances where nutrition labelling is provided voluntarily, the information given must consist of one of two formats – group one (the ‘Big Four’) or group two (the ‘Big Eight’). Group one consists of energy value, protein, carbohydrate and fat; while, group two consists of the latter four plus sugars, saturates, fibre, and sodium. Nutrition labelling may also include starch, polyols, mono-unsaturates, polyunsaturates, cholesterol and any minerals or vitamins that are listed in the legislation.

Nutrition information must be given ‘per 100g or 100ml’. It may also be given ‘per serving size’, provided that the serving size is also stated.

This piece of legislation applies to prepackaged foodstuffs to be delivered to the ultimate consumer and also foodstuffs intended for supply to ‘mass caterers’, ie. restaurants, hospitals, canteens, etc. It does not however, apply to non-prepackaged foodstuffs packed at the point of sale at the request of the purchaser or prepackaged with a view to immediate sale. The legislation pertaining to nutrition labelling and nutrition and health claims is currently under review.

In 2003 the UK Government introduced the Five-a-Day programme (see section 5.7) to encourage and increase consumption of fruit and vegetables. As part of this programme a Five-a-Day logo and portion indicator was developed. Use of the logo and portion indicator must comply with strict criteria which take into account portion size, as well as fat, sugar and salt levels.

The Five-a-Day logo is used on promotional materials, such as printed leaflets, website information, point of sale materials and carrier bags and it may also appear on the label of compliant foods following approval.

The Five-a-Day logo and portion indicator are certification marks under the Trademarks Act (UK) 1994, registered by the Department of Health in the UK and may not be reproduced without a licence from the Department. To be granted a licence, the manufacturer/food producer must show that the use of the logo and /or portion indicator has met the criteria set out.

6.3 Quality Assurance Schemes

6.3.1 Bord Bia Quality Assurance Scheme

Two quality assurance schemes for horticultural produce have been developed in ROI by Bord Bia in conjunction with the FSAI, DAF and industry representatives. The standards were developed in response to consumer concerns and also to assist producers in complying with the relevant legislation. They are based on a number of criteria, including relevant national and EU legislative requirements, and also recognised international quality management systems.

Membership of the schemes is voluntary. Certification to the standard, however, is only granted to processors who meet the relevant requirements and demonstrate on-going compliance in subsequent audits. Audits are conducted independently by the National Standards Authority of Ireland (NSAI). Certification to the standard entitles the producer to use the Bord Bia quality symbol for horticultural produce.

Requirements of the standard are overseen by a Technical Advisory Committee, while a Horticultural Certification Committee makes decisions as to whether to grant or renew, extend, refuse or withdraw certification.

6.3.1.1 Prepared Vegetables Standard

This standard details the requirements for food business operators involved in the preparation and packaging of raw, pre-cut vegetables (ready-to-use) for human consumption (Bord Bia 2004a).

Bord Bia can remove samples of produce for the purposes of testing by an independent laboratory to determine compliance with the requirements of the standard. This testing may include microbial and chemical analysis and any other tests as recommended by Bord Bia's technical advisors.

The standard comprises four main areas:

1. Quality System Core Elements (including quality policy; records; training; HACCP and GMP plans; product identification, traceability and labelling; and product recall).
2. General Hygiene and GMP (including microbiological cross contamination; and pest control).
3. Environmental Hygiene
4. Personal Hygiene
5. Plant and Facilities (including water requirements)

6.3.1.2 Bord Bia Specification for Horticultural Producers

The Bord Bia Specification for Horticultural Producers (Bord Bia 2004b) covers a number of key areas such as cropping practices; quality and hygiene standards in relation to personnel and premises; packhouse; cool chain facilities; crop protection products usage and storage; record keeping; maintaining appropriate documentation; traceability; and implementing environmentally friendly practices.

6.3.2 Assured Produce Scheme

The Assured Produce scheme is a wholly owned subsidiary of Assured Food Standard for the production of assured fruit, salads and vegetables. It is an industry-wide initiative designed to maintain consumers' confidence in the safety and integrity of the produce they eat and has been awarded UKAS accreditation. The scheme is owned by the Assured Produce Company Ltd, a non-profit making company which is comprised of two main bodies: the Assured Produce Scheme Board and the Assured Produce Scheme Council. The Board and Council are made up from representatives of the UK supermarkets, growers, processors and the National Farmers Union (Assured Produce 2006).

The scheme involves registering the crops grown, followed by the completion of the Self Assessment Questionnaire and a visit to the farm by a certifier to verify that the requirements are being met. The scheme licences a number of independent certification bodies to carry out audits. Every member of the scheme is verified once every year (Assured Produce 2006).

The general standard and individual crop protocols are developed and revised annually by authors with specialised knowledge of the crop. This ensures that the consumer benefits from the investment and work undertaken by growers in meeting the standards (Assured Produce 2006).

6.4 Training

Food handlers must receive training in food hygiene in accordance with the Hygiene Package, specifically Regulation 852/2004 on the hygiene of foodstuffs (please refer to Section 3.2.3.3). This is the case for all staff, part-time, full-time or casual, or whether they are employed in the public or private sector.

Due to the growing number of foreign nationals in the horticultural workforce on IOI, there is a need for training in a number of languages. Training is a major focal point in quality assurance schemes, and also in quality standards such as British Retail Consortium, EFSIS and ISO 22000.

6.4.1 Northern Ireland

The FSA recommends three levels of training for food handlers: foundation, intermediate, and advanced. FSA does not provide a database of training providers in NI but recommend three professional bodies for food safety training: the Chartered Institute of Environmental Health, the Royal Institute of Public Health, and the Royal Society for the Promotion of Health.

In NI, cafre (College of Agriculture, Food and Rural Enterprise) provides full-time and part-time courses in horticulture on their Greenmount campus where students develop practical, technical and management skills.

6.4.2 Republic of Ireland

FSAI has a clearly defined food safety training policy (FSAI 2000). It established the Food Safety Training Council (FSTC), which comprises representatives from education and training, the food industry, and inspectors from the official agencies with responsibility for food safety, such as health boards and local authorities. The FSTC advises the FSAI on the contribution to food safety through training; on agreeing levels of skills required for best practice in food safety; and agreeing guidelines for assessing the impact of food safety training in the work environment. The FSAI, with input from the FSTC, has set training standards for the foodservice, retail, and manufacturing sectors. These standards are outlined in a series of food safety training guides covering three levels of skills: induction, additional, and for management.

The FSAI has published a Guidance Note on the Inspection of Food Safety Training and Competence (No. 12), the purpose of which is to establish a consistent approach to the inspection of the training and competence of operational staff dealing with food; and provide advice to food businesses in relation to training.

Bord Bia and Teagasc are involved in training initiatives with people working in the horticultural sector on ROI. Bord Bia provides assistance to the industry in terms of recruiting staff internationally to alleviate labour shortages which threaten the industry. Teagasc provides a number of third level and further education courses in horticulture. These courses take place in a number of locations including horticultural colleges (Warrenstown College, National Botanic Gardens, and Kildalton College) and Institutes of Technology. The courses are accredited by HETAC/FETAC. Teagasc also provides adult and continuing education courses in environment and food safety issues which include pesticide application and food assurance. FÁS (the national training and employment authority on ROI) also provides a number of training courses in horticulture. A number of these courses are conducted in conjunction with Teagasc.

6.5 Organic Produce

‘Organic’ is a term used to describe a particular method of production at farm level, and is as such a ‘process claim’ rather than a ‘product claim’. Organic food constitutes a relatively small but growing part of the food supply chain on IOI. Fruit and vegetables comprise the largest organic food type (approximately 45 percent in ROI (FSAI 2004)).

6.5.1 Production Requirements

Organic produce must be produced in accordance with the standard practices set out by the European Council Regulation 2092/91 as amended, and monitored by certifying bodies in each country (Appendix L). Claims for

organic farming include consideration and application of production methods that do not damage the environment; concern for animal welfare; sustainability; and the production of high quality goods.

Organic farming avoids the use of synthetic fertilisers, chemicals and/or additives. Produce which has been produced by genetic modification or, or contains any such produce cannot be considered organic. This is also the case for produce that has been treated with ionising radiation.

The organic sector on IOI is regulated by DAF (ROI) and DARD (NI). Farmers, growers, processors and importers have to undergo a stringent annual inspection process before receiving a licence from one of the certification bodies to sell their produce as organic. All food produced to these standards is permitted to be labelled with the word 'organic'.

6.5.2 Labelling Requirements

EC Regulation 2092/91 (as amended) also governs the marketing of organic produce and includes requirements on labelling of products at the point of sale. An organic product produced according to EU regulations, should bear the indication 'organic' on the labelling, advertising material or commercial documents. Packaged organic food must indicate the name and/or code number of the organic certification body. The name and address of the producer/other must also be included. Organic products imported from Third Countries must be produced in conformity to EU standards.

6.5.3 Food Safety and Nutrition Aspects of Organic Produce

The question of whether organic food is significantly different to conventional food with respect to nutritional content or quality is still a matter of public and scientific debate, with published literature supporting both sides of the argument (Bonti-Ankomah and Yiridoe 2006). However, while the nutritional composition and quality of foods can be influenced by the farming system used, other factors can also have an effect. These factors include variations in plant or animal varieties, climatic conditions, prevailing soil types and farming practices such as irrigation, crop rotation and fertilising regimes (FSAI 2004).

Organic foods are subject to the same stringent food safety regulations as all food consumed, distributed, marketed or produced on IOI and as such are considered as safe as any other food on the market.

6.5.4 Monitoring of Organic Fruit and Vegetables

Organic fruit and vegetables are grown without artificial pesticides (certain naturally-derived substances are permitted for pest control – see Council Regulation (EEC) No 2092/91). As part of the ROI 2004 monitoring programme, 42 samples of organically-produced fruit and vegetables were analysed (DAF 2006). Of these, 38 showed no detectable levels of pesticides while three samples from Spain and one from France registered pesticide contamination at or near the limit of analytical detection. These did not represent a risk to the consumer although one exceeded the established MRL. It is unknown whether the levels were due to deliberate use of pesticides during growing or contamination during subsequent handling.

Organic produce was also sampled as part of the UK 2004 pesticide residue monitoring programme. The actual number of samples tested that were organic is not stated in the 2004 report. However, it does state that the number reflects consumer purchasing habits. Residues were found in a sample of Chilean apples and Spanish strawberries. There were no MRL breaches.

6.5.5 Authenticity

While the farming systems can differ substantially, it is difficult to distinguish between the end products of organic farming and their conventionally produced counterparts. There is no recognised scientific test to differentiate between organic and conventional produce. However, the presence of certain pesticide residues, growth promoters or genetically modified material in a food product could indicate that the food was not produced to organic standards which would prohibit it from being labelled organic.

6.6 Genetic Modification

Genetically Modified Organisms (GMOs) are defined in the legislation as organisms, with the exception of human beings in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination (Article 2 of Directive 2001/18/EEC).

Genetic modification of plants can offer the opportunity to produce more vigorous crops with higher yields. It can also be used to confer herbicide tolerance, virus resistance, delayed ripening and other traits on plants for food use. EU legislation on GMOs has been in place since the early 1990s and has two main objectives. Firstly, to protect human health and the environment, and secondly, to ensure the free movement of safe genetically modified (GM) products in the EU. A GM organism and any associated food or feed product can only be put on the EU market after being approved on the basis of a detailed safety assessment. The authorisation procedure is based on a scientific assessment of risks to human and animal health and the environment. Only foods that have undergone the authorisation process as detailed in EU Regulation (EC No. 1829/2003) may be sold in the EU. Ingredients from maize, soya bean and oilseed rape are the most common types of GM foods currently on the EU market (FSAI 2002). The FSA in NI and the FSAI in ROI are responsible for enforcing GM food regulations on IOI and in doing so monitor the market to ensure only EU-authorized GM foods made available and that they are labeled appropriately.

EU legislation provides for the labeling of foodstuffs when authorized GM material is present at a proportion of greater than 0.9 percent of the total ingredient. A food may contain an authorized GM ingredient at 0.9 percent or less without labeling if it can be shown that its presence is adventitious or technically unavoidable. GM foods that have been through the authorization process and currently on the EU market are considered as safe as their conventional counterparts (FSAI 2002).

Perceived concerns about GM include food safety; potential damage to the environment; disruption of ecosystems; and ethical and moral objections.

Table 6.4 outlines legislation pertaining to genetically modified food.

Table 6.3 EU legislation relating to GM food

Directive 2001/18/EC	On the deliberate release into the environment of GMOs
Regulation (EC) No. 1829/2003	The authorisation and labelling of GM food and feed
Regulation (EC) No. 641/2004	Rules for the implementation of Regulation (EC) No. 1829/2003 in regard to the application process
Regulation (EC) No. 1946/2003	Transboundary movements of GMOs between MS, EU and Third Countries
Regulation (EC) No. 1830/2003	Concerning the traceability and labelling of GMOs and the traceability of food and feed products produced from GMOs
Council Directive 90/219/EEC	On the contained use of GMOs

7. Conclusions

7.1 Introduction

Fresh fruit and vegetables are key components of a healthy diet. The associated infectious disease risks are low and mechanisms by which contamination occurs are preventable. Good hygiene and agricultural practices from farm to fork can prevent contamination and microbial growth in these products. The public health challenge is clear. To promote and increase the consumption of fruit and vegetables while also promoting and enforcing strict hygiene measures and agricultural practices that ensure safe fresh produce for consumers.

Fruit and vegetables are increasingly being recognised as an emerging vehicle for foodborne illness in humans. Traditionally meat, milk and egg products were the 'usual suspects'. However, the consumption of fresh produce (fruit and vegetables) has now been linked, both epidemiologically and microbiologically to outbreaks of infectious intestinal disease. Consumption of this food group, however, represents only a small number of the total reported cases, although international epidemiological evidence indicates that this number is in fact increasing.

This review has collated and considered the information available – academic, regulatory, public health – on the safety and health implications of raw vegetables and fruit. On the basis of the evidence the review draws the following conclusions (based from farm to fork), which may provide the basis for action for **safefood** and other agencies on the island, as well as for stakeholders, public health professionals and consumers.

7.2 Conclusions

7.2.1 Primary Producers and Packers

- Many food pathogens are commonly found in soil where the edible portion of vegetables are grown either directly in soil (root vegetables) or in close proximity to the soil (leafy vegetables), thus creating potential for direct contamination during growing. While recognising that the total elimination of the risk of soilborne contamination may be impossible, thorough washing prior to packaging should serve to remove as much soil as possible.
- With respect to fruit products, these can be contaminated via soil if the fruit has dropped from trees. The practice of using dropped or fallen fruit should be avoided, as the produce may have become bruised or the skin may have been broken, allowing internalisation of bacteria.
- Transmission of pathogens can occur directly from animals, birds and insects. Many animals can act as reservoirs for certain human pathogens and if the faeces of these animals come into contact with fresh produce, contamination can occur. Animals should be prevented from entering fields and measures should be taken to prevent animal waste contaminating crop fields or water supplies particularly during heavy rainfall.
- Where organic material such as manure is being used as fertiliser, there are guidelines for growers which aim to minimise the risks of microbiological contamination of RTE crops. These guidelines should be followed to prevent contamination with potentially dangerous bacteria such as *E.coli* 0157:H7.
- Growers should identify the sources of water used for a particular purpose and minimise contamination from livestock, run-off, heavy rainfall and excess irrigation. It is also recommended that the microbial and chemical quality of the water is tested at appropriate intervals. Potable or clean water should be used.
- Field worker hygiene is important as hands are used in much of the harvesting process. Thus, the importance of personal hygiene should be stressed.
- To prevent cross-contamination during harvesting, thorough cleaning and decontamination of equipment, containers and transport vehicles should be undertaken.

7.2.2 Processors and Distributors

- It is important that hygienic practices are followed throughout the processing of fresh produce and that raw materials and finished product are stored and handled in such a manner as to prevent contamination and damage which may lead to internalisation of organisms.
- The temperature used during processing should be controlled to prevent product spoilage and also to prevent the growth of pathogens.
- Worker hygiene is central in the prevention of cross-contamination.
- During trimming and peeling:
 - The edible portions should be conveyed to a segregated, hygienic, temperature controlled area within ten minutes for further processing.
 - To prevent structural damage, the peeling process should be as gentle as possible. Manual peeling causes less damage but this is not always an economically viable option. The use of a sharp knife blade is recommended as it will cause less damage.
 - Peeling and other machinery should be thoroughly cleaned and disinfected regularly to avoid microbial build up, growth and subsequent contamination of the produce.
- Some produce items that have a high water content, e.g. unwaxed apples, celery and tomatoes, are susceptible to microorganisms entering the skin via the stomata and through stem scars on the calyces of fruits, or through damage to the skin. Surface washing will not wash these internalised bacteria thus the wash water should be maintained 10°C above the temperature of the produce.
- Following decontamination with chlorine a final washing step should be included with non-chlorinated rinse water, which has been chilled to 1°C to 2°C. This step will remove traces of chlorine and reduce the product temperature to 5°C, thus increasing its shelf-life.
- The development of technologies such as MAP and CAP used to extend the shelf-life are of great economic importance to the fresh produce industry and the resulting products popular with the consumer because of their convenience. However, MAP alone is not sufficient to prevent pathogen growth, chilling at 5°C or less is essential, while HACCP, GMP and GAP should be in place to prevent pathogen contamination throughout the supply chain.
- Staff suffering from acute gastrointestinal symptoms are required by law to report their condition to their employer, be excluded from handling food and to seek medical advice before being allowed to return to their duties. It is the employers' responsibility to ensure that this is adhered to.
- The requirement for suitable sanitary conditions, such as adequate hand washing and toilet facilities, at all stages within the food production chain, including primary production is at the core of ensuring safe fruit and vegetables for the consumer.
- Processing of fruit and vegetables will influence the nutritional value of the final product. This is particularly relevant to processes that involve the addition of heat as heat sensitive micro-nutrients will be most affected. It is also relevant to the addition of water and ingredients such as salt and sugar.
- Not only will the chill chain ensure the safety of fruit and vegetables, cool temperatures are an effective method of retaining the nutritional value of fruit and vegetables.

7.2.3 Retailers and Caterers

- The retailer and caterer represent the front line of the food industry to consumers. Food business operators have a legal responsibility in ensuring food safety.
- Worker hygiene and hygienic practices are legal requirements and are central in the prevention of cross-contamination.

- HACCP and training are at the core of good food safety practice. The influx of foreign-nationals into IOI, and their uptake, in large numbers, of employment within the horticultural sector, has put even more emphasis on the need for training, including that within their native languages.
- Cooking is a necessary part of making many fruits and vegetables edible. The use of excessive water and heat should be avoided to retain the micronutrient composition and methods such as microwaving and steaming should be considered. Overcooking and storage over long periods should be avoided.
- The nutritional content of fruit and vegetables can be altered appreciably by the addition of ingredients such as sugar, creams, sauces and salad dressings. In some cases this can turn a low energy food into an energy dense food. Consumers should be offered the choice of adding these ingredients themselves.

7.2.4 Consumers

- Raw fruit and vegetables are highly nutritious. They are a low energy dense and fibre rich food source in the diet offering a diverse range of micronutrients. Variety in choosing fruit and vegetables is important in obtaining the full benefits of the nutrients found in the different types.
- Aim for at least five portions a day (400g/day), including tinned, frozen and dried varieties.
 - Juice, while it does count towards a portion, is not a replacement for raw fruit and vegetables as it does not have fibre to the same extent.
 - Smoothies (mash/pulp) are nearer to raw fruit and vegetables than juice and therefore a good option.
- Cooking is a necessary part of making many fruit and vegetables edible. The use of excessive water and heat should be avoided to retain the micronutrient composition, and methods such as microwaving and steaming should be considered.
- The addition of ingredients to fruit and vegetables, such as sugar, creams and sauces can alter the nutritional content. When purchasing processed fruit and vegetable products avoid those that have additional salt, sugar and fat added. In the home the use of low-fat alternatives to cream such as yogurt and crème fraîche and the avoidance of salt during cooking are recommended. Alternatives to salt during cooking include lemon juice, garlic, ginger, pepper, and herbs and spices.
- There should be an emphasis placed on the importance of reading labels of prepared and/or Ready to Eat (RTE) fruit and vegetables.
- RTE fruit and vegetables are eaten in their raw, uncooked form and it is thus essential that these commodities are free from contamination. Washing or peeling of fruit and vegetables is not required as a protection against pesticide residues; however, it is sensible to wash fruit and vegetables before consumption for reasons of general food hygiene. The most efficient method is to rub or brush fresh produce under cold running tap water.
- Pre-packed vegetables in MAP or CAP are safe to eat and should be stored at 5°C.
- It is not necessary to store non-prepackaged fruit at refrigerated temperatures; however, fruit and vegetables stored at room temperature have been shown to lose some of their nutritional value more quickly compared to those which have been stored under refrigeration. Unripe bananas should not be stored in a refrigerator as this interrupts the ripening cycle and thus should be left at room temperature.
- There is potential for contamination from raw meat and poultry to RTE fruit and vegetables. Therefore, it is essential that all steps are taken during food storage and preparation to prevent such cross-contamination from taking place. This includes:
 - washing hands before food preparation and after handling raw meat and poultry, and
 - keeping raw and RTE foods completely separate by adequately decontaminating utensils and cutting boards between use.

7.2.5 Health Professionals

- In spite of the claimed knowledge of the Five-a-Day message, intakes of fruit and vegetables on IOI remain low. Therefore, there is a need to continue to promote this message, particularly amongst children and younger people, and clarify uncertainties such as the definition of portion sizes, as well as raising awareness of the health benefits of fruit and vegetables.
- Within promotional activities the barriers to consumption, such as accessibility to fresh fruit and vegetables (particularly amongst lower socio-economic groups) and attitudes and awareness should be addressed. This requires a multi-strategic approach.

7. Appendices

Appendix A Examples of portion sizes of fruit and vegetables

	Portion Equivalent to 80g (As eaten, edible portion, and drained if canned)
Fruit	
Apple, dried rings	4 rings
Apple, fresh	1 medium apple
Apple, puree	2 heaped tablespoons
Apricot, dried	3 whole
Apricot, fresh	3 apricots
Avocado	Half an avocado
Banana chips	1 handful
Banana, fresh	1 medium banana
Blackberries	1 handful (9 to 10 blackberries)
Blackcurrants	4 heaped tablespoons
Blueberries	2 handfuls (4 heaped tablespoons)
Cherries, fresh	14 cherries
Clementines	2 clementines
Currants, dried	1 heaped tablespoon
Dates, fresh	3 dates
Fig, dried or fresh	2 figs
Fruit juice	1 x 150ml
Fruit salad, canned or fresh	3 heaped tablespoons
Fruit smoothie	1 x 150ml
Gooseberries	1 handful (3 heaped tablespoons)
Grapefruit segments, canned	(8 segments)
Grapefruit, fresh	Half a grapefruit
Grapes	1 handful
Kiwifruit	2 kiwifruit
Mandarin orange, canned	3 heaped tablespoons
Mandarin orange, fresh	1 medium orange
Mango	2 slices (2-inch slice)
Melon	1 slice (2-inch slice)
Mixed fruit, dried	1 heaped tablespoon
Nectarine	1 nectarine
Orange	1 orange
Passion fruit	5 to 6 fruit
Papaya, fresh	1 slice

Portion Equivalent to 80g (As eaten, edible portion, and drained if canned)	
Fruit	
Peach, canned	2 halves or 7 slices
Peach, dried	2 halves
Peach, fresh	1 medium peach
Peach, ready to eat	2 halves
Pear, canned	2 halves or 7 slices
Pear, dried	2 halves
or ready to eat	
Pear, fresh	1 medium pear
Pineapple, canned	2 rings or 12 chunks
Pineapple, dried	1 heaped tablespoon
Pineapple, fresh	1 large slice
Plum	2 medium plums
Prune, canned	6 prunes
Prune, dried or ready to eat	3 prunes
Raisins	1 tablespoon
Raspberries, canned	20 raspberries
Raspberries, fresh	2 handfuls
Rhubarb, cooked	2 heaped tablespoons
Satsuma	2 small satsumas
Strawberry, canned	9 strawberries
Strawberry, fresh	7 strawberries
Sultanas	1 heaped tablespoon

Adapted from: Department of Health (2003)

	Portion Equivalent to 80g (As eaten, edible portion, and drained if canned)
Vegetables	
Artichoke	2 globe hearts
Asparagus, fresh	5 spears
Aubergine	1/3rd aubergine
Beans, black eye or kidney, cooked	3 heaped tablespoons
Beans, French, cooked	4 heaped tablespoons
Beetroot, bottled	3 'baby' whole, or 7 slices
Broccoli	2 spears
Brussel sprouts	8 Brussel sprouts
Cabbage	1/6th small cabbage or 2 handfuls sliced
Cabbage, shredded	3 heaped tablespoons
Carrots, fresh, slices	3 heaped tablespoons
Carrots, shredded	1/3 cereal bowl
Cauliflower	8 florets
Celery	3 sticks
Chickpeas	3 heaped tablespoons
Courgettes	Half a large courgette
Cucumber	2-inch piece
Leeks	1 leek (white portion only)
Lettuce (mixed leaves)	1 cereal bowl
Mangetout	1 handful
Mixed vegetables, frozen	3 tablespoons
Mushrooms, button	3-4 heaped tablespoons, 14 button or 3 handfuls of slices
Onion, fresh	1 medium onion
Parsnips	1 large
Peas: canned, fresh, frozen	3 heaped tablespoons
Pepper: canned, fresh	Half a pepper
Spinach, cooked	2 heaped tablespoons
Spinach, fresh	1 cereal bowl
Spring onion	8 onions
Sugarsnap peas	1 handful
Swede, dice and cooked	3 heaped tablespoons
Sweetcorn, baby	6 baby corn
Sweetcorn, canned	3 heaped tablespoons
Sweetcorn, on the cob	1 cob
Tomato puree	1 heaped tablespoon
Tomato, canned plum	2 whole tomatoes
Tomato, fresh	1 medium, or 7 cherry
Tomato, sundried	4 pieces

Adapted from: Department of Health (2003)

Appendix B Climate types for fruit and vegetables

Fresh fruit

Temperate	Tropical and subtropical (incl. exotics)
Apples/pears	Bananas
Grapes	Citrus fruit
Deciduous fruit (peaches, nectarines, apricots, cherries, etc.)	Pineapples
Berries (strawberries, raspberries, blueberries, etc.)	Avocados
Melons/watermelons	Mangoes
	Lychees
	Papayas
	Others: passion fruits, dates, figs, etc.

(Profound 2004)

Fresh vegetables

Temperate	Tropical and subtropical
Tomatoes	Cassava
Onions/shallots/garlic	Arrowroot
Beans and peas	Yams
Asparagus	Sweet potatoes
Courgettes	Dasheen
Eggplants	Breadfruit
Capsicum	
Sweet maize	

Profound (2004)

Appendix C Leading suppliers of fruit and vegetables to the EU

Bananas	Ecuador (16%), Costa Rica (15%), Belgium (14%), Colombia (12%), Panama (6%), France (6%), Germany (5%), Cameroon (5%)
Apples	France (21%), Italy (17%), New Zealand (12%), The Netherlands (10%), Belgium (8%), Chile (8%)
Grapes	Italy (22%), South Africa (18%), The Netherlands (10%), Spain (9%), Chile (9%), Belgium (6%)
Berries	Spain (45%), The Netherlands (11%), Belgium (8%), Morocco (8%), France (5%), Italy (5%)
Pears	The Netherlands (18%), Italy (16%), Argentina (15%), South Africa (11%), Belgium (11%)
Oranges	Spain (56%), South Africa (10%), The Netherlands (5%), Morocco (5%), Belgium (3%)
Mandarins	Spain (70%), Morocco (6%), Turkey (4%), South Africa (3%), The Netherlands (3%)
Lemons, limes	Spain (48%), Argentina (19%), The Netherlands (9%), Brazil (4%), South Africa (3%)
Grapefruit	USA (25%), South Africa (16%), The Netherlands (11%), Turkey (9%), Israel (9%)
Melons	Spain (44%), Brazil (11%), The Netherlands (9%), Costa Rica (9%), France (6%), Morocco (4%)
Peaches	Spain (44%), Italy (33%), France (11%), The Netherlands (2%), South Africa (2%), Greece (2%)
Cherries	Turkey (27%), Spain (17%), France (8%), Italy (8%), Greece (6%), The Netherlands (5%)
Kiwi Fruits	Italy (29%), New Zealand (25%), Belgium (17%), Chile (11%), France (7%)
Pineapples	Costa Rica (27%), Côte d'Ivoire (19%), France (14%), Belgium (9%), Ghana (8%)
Avocados	Israel (20%), Spain (20%), South Africa (19%), The Netherlands (9%), France (9%), Mexico (7%)
Tomatoes	Spain (41%), The Netherlands (32%), Morocco (7%), Belgium (6%), Italy (6%), France (3%)
Onions	The Netherlands (23%), Spain (23%), France (9%), Italy (7%), New Zealand (7%), Belgium (6%)
Peas and Beans	Kenya (20%), Morocco (14%), Spain (14%), France (12%), The Netherlands (10%), Egypt (6%)
Mushrooms	The Netherlands (28%), Ireland (24%), Poland (12%), Belgium (7%), Germany (4%)
Asparagus	Spain (33%), Greece (21%), Peru (16%), The Netherlands (10%), Hungary (5%), France (3%)
Courgettes	Spain (68%), Morocco (10%), The Netherlands (7%), France (6%), Italy (4%), Germany (2%)

Source: Profound (2004)

Appendix D The Hygiene Package

The new Hygiene Package comprises the following legislation:

- Regulation 852/2004 on the hygiene of foodstuffs.
- Regulation 853/2004 laying down specific hygiene rules for food of animal origin.
- Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption.
- Directive 2002/99 laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption.
- Directive 2004/41 repealing certain directives concerning food hygiene and health conditions for the production and placing on the market of certain products of animal origin intended for human consumption and amending
- Council Directives 89/662 and 92/118 and amending Decision 95/408.
- Regulation 2073/2005 on microbiological criteria for foodstuffs.

Appendix E Nutritional composition of different classes of fruit and vegetables

Vegetables – generally a good source of NSP/fibre, vitamin C, folate, potassium and phytochemicals

Type	Examples	Nutritional Value
Roots	Carrots, beetroot, parsnips, swede and turnip	Typically high in water and low in protein components. The carbohydrate is found as a mixture of sugar and starch and there are lower amounts of fibre than found in other vegetables. Low concentrations of micro-nutrients such as folate, vitamin C, calcium are found. Carrots and beetroot are rich sources of carotenoids (or their precursors).
Leafy Vegetables	Cabbages, brussels sprouts, cauliflower, kale, broccoli, lettuce, chicory, endive, celery, many herbs, spinach	Typically high in water and low in dry matter content. They do contain small amounts of protein, sugar and fibre. They are consumed in large portions and contribute to intake of carotenoids, folates, vitamin C, potassium, magnesium and many trace elements. Also a source of haem iron and calcium.
Onions	Onions, leeks, chives	Similar nutritional composition to leafy vegetables
Legumes – beans and pulses	Peas, beans and lentils	A good source of protein (of good biological value) particularly the seed legumes including haricot, lentil, mung and soya beans. They are a rich source of starch and fibre, vitamins and inorganic matter. They are also a source of haem iron. Peas and beans such as runner, broad and French beans are a good source of vitamin C. Lentils are a source of zinc.
Vegetables consumed as their fruits	Cucumbers, marrows, courgettes, pumpkins and squashes, sweet peppers	High water content, low nutritional content, great for adding in texture and taste. Good source of vitamin C

Fruits – generally a good source of Vitamin C, potassium, fibre/NSP and phytochemicals. Fruit is generally higher in sugar than vegetables.

Examples	Nutritional Value
Tomatoes	Rich source of carotenoids and significant source of Vitamin C
Apples and pears	Source of sugar and vitamin C
Stone fruits e.g. plums, peaches, apricots, cherries	Source of vitamin C and skin of peaches and apricots a good source of carotenoids
Berries	Good source of vitamin C
Currants	Good source of vitamin C
Citrus fruits	Rich source of vitamin C. Oranges a good source of folate and carotenoids and potassium. Melons are a significant source of carotenoids and vitamin C
Grapes	Low in fibre and Vitamin C. Rich in bioactive compounds.
Banana	Good source of starch and excellent source of potassium
Dates	Rich source of sugars and contain low amounts of vitamins

Adapted from Southgate (2000)

Appendix F Mean daily intake of vegetables (excluding potatoes) in Irish men and women aged 18 to 64 years

	Men (n=662)			Women (n=717)			Total (n=1379)		
	% Consumers	Mean (g/d)	SD	% Consumers	Mean (g/d)	SD	% Consumers	Mean (g/d)	SD
Peas, beans and lentils	85	30.9	33	78	17.1	19	82	23.8	27
Peas	67	13.6	19	64	8.1	10	65	10.7	15
Baked beans	45	16.4	26	37	8.2	14	41	12.1	21
Green vegetables	67	15.8	20	72	13.9	16	70	14.8	18
Broccoli	35	5.1	10	43	5.3	9	39	5.2	9
Cabbage	37	7.0	16	37	5.5	10	37	6.2	13
Green beans	13	1.6	5	13	1.3	4	13	1.4	5
Carrots	81	20.2	25	84	17.3	18	82	18.7	22
Salad vegetables	53	4.2	8	68	6.5	11	61	5.4	10
Lettuce	52	3.4	6	66	4.6	8	59	4.0	7
Tomatoes	81	26.3	29	89	29.5	28	85	27.9	29
Other vegetables	97	51.3	40	99	47.9	36	98	49.6	38
Mushrooms	49	5.8	11	51	4.9	8	50	5.3	10
Onions	88	14.6	15	88	12.1	12	88	13.3	13
Peppers	36	4.1	11	44	4.3	8	40	4.2	10
Cauliflower	24	3.5	8	27	3.1	7	25	3.3	8
Total vegetables	100	148.7	78	100	132	68	100	140.2	73

Source: Irish Universities Nutrition Alliance (2001)

Appendix G Mean daily intake of fruit in Irish men and women aged 18 to 64 years

	Men (n=662)			Women (n=717)			Total (n=1379)		
	% Consumers	Mean (g/d)	SD	% Consumers	Mean (g/d)	SD	% Consumers	Mean (g/d)	SD
Fruit Juice	41	33.1	65	48	33.8	55	45	33.5	60
Orange Juice	35	29.3	55	40	28.6	51	37	28.9	53
Citrus Fruit	34	22.9	55	41	23.4	47	38	23.2	51
Oranges	28	20.3	50	34	20.8	45	31	20.5	48
Bananas	44	27.9	51	55	26.6	37	49	27.2	44
Apples	62	29.5	44	66	32.7	47	64	31.2	46
Other fruit	50	19.4	41	62	31.8	61	56	25.8	53
Pears	13	5.6	20	17	6.2	19	15	5.9	20
Dried fruit	18	1.7	6	12	1.4	5	21	1.5	5
Total fruit	88	132.8	148	92	139.6	136	90	136.3	142

Source: Irish Universities Nutrition Alliance (2006)

Appendix H Percentage of individuals complying with the current UK and ROI recommendation of five or more portions of fruit and vegetables per day and the USDA's recommendation of three portions of vegetables and \geq two portions of fruit per day

	Men (n=662)				Women (n=717)			
	18-35y	36-50y	51-64y	All	18-35y	36-51y	51-64y	All
\geq 5 servings of fruit and vegetables (ie. 400g or more)	17.4	25.4	21.4	21.3	12.6	19.9	27.2	18.8
3 portions of vegetables	9.0	11.9	9.8	10.3	4.1	7.0	6.8	5.9
\geq 2 portions of fruit	26.9	34.3	32.4	31.0	26.4	34.6	40.1	32.8

Source: Irish Universities Nutrition Alliance (2006)

Appendix I Intake of fruit and vegetables among 5 to 12 year olds in ROI in the National Children’s Survey

	Boys		Girls		All	
	Mean (g/d)	SD	Mean (g/d)	SD	Mean (g/d)	SD
Vegetable and pulse dishes	5	25	5	13	5	20
Peas, beans and lentils	14	19	11	18	13	18
Green vegetables	6	10	6	10	6	10
Carrots	11	14	8	11	9	13
Salad vegetables	2	7	5	12	3	10
Other vegetables e.g. onions	9	15	9	18	9	16
Tinned or jarred vegetables	1	6	1	3	1	4
Total Vegetables	48		45		46	
Fruit Juices	84	108	103	122	94	115
Bananas	18	29	15	23	16	26
Other fruits e.g. apples, pears	40	47	42	44	41	46
Citrus Fruit	10	22	11	21	10	21
Tinned Fruit	1	8	2	6	1	7
Total Fruit	153		173		162	

Irish Universities Nutrition Alliance (2001)

Appendix J Contribution of fruit and vegetables to nutrient intakes in the adults on IOI and primary school aged children in ROI

	Vegetables		Fruit	
	NSIFCS	NCS*	NSIFCS	NCS**
Protein	3.3	2.3	0.9	low
Fat	2.1	1.3	0.3	low
Carbohydrate	3.3	1.6	5.4	7.5
Energy	2.7	1.6	2.7	4.2
Total sugars	5.5		13.6	
Starch	2.0		0.2	
Fibre (Southgate)	16.9		5.5	
Fibre (Englyst)	19.0		7.7	
Potassium	6.7		2.2	
Calcium	4.2		2.0	
Magnesium	5.4		4.2	
Phosphorus	4.4		1.4	
Iron	7.5		2.0	
Copper	3.8		11.3	
Zinc	3.8		0.9	
Retinol	0.2		0.0	
Carotene	63.0		1.7	
Total Vitamin A	32.1		1.2	
Vitamin D	0.0		0.0	
Vitamin E	12.7		5.0	
Thiamin	6.6		3.5	
Riboflavin	2.8		1.9	
Total niacin equivalents	7.5		1.4	
Vitamin B6	5.4		4.2	
Vitamin B12	0.0		0.0	
Folate	10.6		5.0	
Pantothenate	5.5		2.3	
Biotin	3.9		3.6	
Vitamin C	23.7		25.0	

* Note the classification is vegetables and vegetable dishes and does not include disaggregated data and composite meals

** Note the classification is Fruit and fruit juices and does not include disaggregated data and composite meals

Note: where data is missing there was no data available at time of compilation.

Source: Irish Universities Nutrition Alliance (2001; 2006)

Appendix K Quality class

Category	Requirement
Extra Class	Produce of excellent quality (applies only to specially selected produce – see below)
Class I	Good quality produce, well-shaped and coloured, and generally free of blemishes and marks
Class II	Produce of sound marketable quality with certain allowances in relation to shape, colouring and slight minor defects such as blemishes, healed cracks or marks

Class I and II apply to all products, whereas Extra class applies only to the following products:

Fruits	Apples, apricots, avocados, cherries, kiwifruit, lemons, mandarins, nectarines, oranges, peaches, pears, plums, satsumas (together with clementines, tangerines and similar citrus hybrids), strawberries and table grapes
Vegetables	Artichokes, asparagus, beans (other than shelling beans), carrots, cauliflower, chicory, cucumbers, garlic, mushrooms, tomatoes

Appendix L Organic certification bodies on IoI

DAF in RoI has approved three organic organisations for certification and inspection services, namely:

- i Bio-dynamic Agricultural Association of Ireland (“Demeter”),
- ii Irish Organic Farmers and Growers Association (IOFGA), and
- iii Organic Trust Ltd.

DARD in NI has approved three organic organisations in addition to the above:

- iv Soil Association,
- v Organic Farmers and Growers, and
- vi Organic Food Federation.

Glossary

Alliums	Include onions & leeks.
Berries	Small roundish juicy fruits without a stone, the most commonly grown soft fruits.
Brassicas	Include cabbage, cauliflowers and broccoli.
Centralised Distribution Centre	Producers deliver to a single CDC location, and the CDC then arranges for distribution to its own outlets.
Epiphytic Flora	Organisms that grow on plants but are not parasitic to them.
Field Vegetables	Include brassicas, root crops, outdoor lettuce, celery and peas.
Food Miles	The distance that food travels from the farm to consumers. The rise in food miles has led to increases in the environmental, social and economic burdens associated with transport ⁸ .
Fruit	The edible products of a plant or tree containing seed.
Glycaemic Index (GI)	This is a way of comparing carbohydrate foods to simple sugars to see how quickly that food will make blood sugar levels rise. The carbohydrates in low GI foods are released more slowly into the blood stream, which means that blood sugar levels stay steady. This means that you are less likely to feel peaks and troughs in your energy levels. High GI foods release their blood sugars quickly, giving you a jolt of energy.
Phytochemicals	Also known as bioactive substances, are compounds commonly found in plant foods that are not considered to be nutrients but may have beneficial effects on health, helping to protect against a number of diseases such as heart disease and cancer.
Protected Food Crops	Food crops that are grown under protective covers (glasshouse, polythene tunnels) for their entire growing season (to allow for extension of same).
Root Crops	Include carrots, swedes and parsnips.
Salad Crops	Include scallion, herb.
Soft Fruit	Fruits grown on runners, canes or bushes.
Third Country	A country outside of the European Union.
Top Fruit	Fruits grown on trees.

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