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Code of Practice For Food Safety in the Fresh Produce Supply Chain in Ireland

Code of Practice
No. 4

Code of Practice For Food Safety in the Fresh Produce Supply Chain in Ireland

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Foreword

Fruit and vegetables are an important source of nutrition and a vital component of a healthy balanced diet. A recent report by the Cardiovascular Health Strategy Group[1] reiterated the findings of the Nutrition Advisory Group[2] on dietary guidelines, where at least four servings of fruit and vegetables per day were recommended. The Department of Health and Children, the Food Safety Authority of Ireland and Bord Glas are involved in initiatives aimed at increasing the consumption of fruit and vegetables by the Irish population.

The importance of food safety has risen in the public consciousness due in part, to a series of well publicised food scares and in part to high profile awareness campaigns run by the Food Safety Authority of Ireland. Food safety is a shared responsibility. Everyone involved in the food chain from farm to fork must take responsibility for safeguarding the food supply. Fruit and vegetables are eaten in their raw and cooked form and it is therefore essential that these commodities are free from contamination, whether chemical or microbiological in nature. An increase in fruit and vegetable consumption must be supported by consumer confidence and that requires an exemplary safety record.

This code of best practice is aimed at people involved in the supply of fresh produce to the consumer in Ireland. It is based on similar codes of best practice from other countries, international organisations and research institutes. This code of best practice is designed to compliment existing Quality Assurance initiatives and standards. Best practice is a target that everyone involved in the industry should strive to achieve and this code will be an essential reference for increasing food safety standards.

Background

In Ireland, a number of Government health and nutrition initiatives have been delivered to encourage the Irish people to eat more fruit and vegetables and if they are successful, it is envisaged that increased consumption of fresh produce will occur in the future. The Irish fresh produce industry has not been linked to any outbreak of microbial food poisoning, although there have been a small number of incidents following the illegal use of pesticides. However, in some other countries there is an increasing recognition of chemical and microbiological food poisoning resulting from the consumption of fresh produce. Fresh produce is either consumed raw or after minimal cooking. It is vital therefore that it is not contaminated prior to sale to the consumer.

In 1998 the World Health Organisation issued a report on surface decontamination of fruits and vegetables that can be eaten raw.[3] This report serves as an excellent summary of microbial contamination of produce and a review of the science and technology available to reduce the risk. The first governmental approach to the problem was taken in 1998, when the United States Department of Agriculture issued a guide to Fruit and Vegetable Decontamination.[4] This was a code of practice for the horticultural industry, to help reduce the risk of microbial infection resulting from the ingestion of raw fruit and vegetables.

The recently published Food Safety Authority of Ireland report on the risk of *E. coli* O157 infection also outlined the risk of foodborne illness from eating contaminated fruit and vegetables.[5] It recommended the development of an Irish code of practice for the horticulture industry to reduce the risk of *E. coli* O157 infection from fruit and vegetables. However chemical hazards should not be ignored and therefore a best practice guide must take into account both chemical and microbiological criteria.

To assist with this work the Food Safety Authority of Ireland established a steering group, comprising of people involved in the fresh produce chain and scientific experts to oversee the development of a code of best practice for the Irish horticultural industry. The following code is not intended to be a guide to legislation or an interpretation of legislation. Instead, it aims to highlight the hazards and identify control measures in key risk areas of the fresh produce supply chain. Whilst recognising the high standards of practice that exist in Ireland, this guide aims to illustrate the steps that can be taken towards the production of safer fruit and vegetables.

It is in the hands of the horticulture industry to take responsibility for the production of safe fresh produce. By implementing the recommendations in this guide, you will help to minimise the risks of a food poisoning outbreak associated with fresh produce. This will protect both the consumer and your business.

Purpose

To publish a practical guide to best practice in all sectors of the Irish fruit and vegetable industry, designed to minimise the risk of food-borne illness resulting from consumption of fruit and vegetables.

Scope

- Fresh produce safety
- Conventional growing
- Organic growing
- Seed production (where applicable) and sowing including ground preparation
- Pathogenic micro-organisms
- Pesticides
- References to chemical codes of practice where necessary
- Fresh produce supply from the farm to the consumer.

The following items were not considered in this document:

- Fresh produce quality
- Consumer fresh produce handling and use
- Environmental protection (other than where it affects food safety)
- Detailed pesticide usage instructions
- Detailed chemical usage instructions
- Preservatives
- Produce processing other than pre-prepared fresh processes.

Glossary of Terms

Name	Description
Acute toxin	Poison that exerts a harmful effect within a short time of exposure.
Antimicrobial	Any chemical that can kill micro-organisms (see disinfectant).
Bean sprout	Sprouted seeds as food for human consumption.
Biocides	A broad category of chemicals and biological products used to control harmful organisms excluding plant protection products.
Biosolids	The organic by-product of urban waste-water treatment.
Chronic toxin	Poison that accumulates in small amounts in the human body over time and eventually exerts a harmful effect.
Composting	A biological process in which soil-inhabiting micro-organisms break down plant tissue to form humus.
COSHH	The Control Of Substances Hazardous to Health.
Contamination	Presence of micro-organisms and their by-products or chemicals and their breakdown products at a level sufficient to cause a potential health hazard.
Detergent	A chemical used to remove debris and soil but does not kill micro-organisms.
Disinfectant	A chemical that has the ability to kill micro-organisms but does not aid in the removal of debris and soil.
Farmyard manure	Excrement of farm animals, faeces and urine often mixed with straw from bedding.
Flocculation	Aggregation of particles into a solid mass.
Fresh produce	Fruit and vegetable items that are listed in the Bord Glas Act.
Ground water	Water that has percolated through the soil from the surface and is available in porous rock beneath the surface.
HACCP	Hazard Analysis and Critical Control Point – A system that identifies, evaluates and controls hazards which are significant to food safety.
Hazard control	Actions or activities that are required to prevent, eliminate or reduce a hazard to acceptable levels.

Name	Description
Horticultural Industry Forum	A representative group of the key people in the horticultural supply-chain. The Forum was set up in 1995 to create greater co-ordination, co-operation and communication within the horticultural industry. The Forum functions as a sub-committee of Bord Glas (under Section 14 of the Bord Glas Act, 1990).
Manure leachate	The nutrient rich fluid that is produced during the decay of manure.
Micro-organisms	Includes bacteria, protozoa and viruses.
Organic	As defined in Council Regulation 2092/91/EEC on organic production of agricultural products.
Pathogens	Micro-organisms with the potential to harm public health.
Pesticide	Any preparation (chemical or biological) that is used to kill or control harmful or undesired organisms or plants, or to regulate plant growth.
Potable water	Water that is of drinking water standard as defined in the legislation 'European Communities (quality of water intended for human consumption) Regulations 1988 (due for amendment in 2000).
Protozoa	Single celled animals, some of which can cause human disease.
Risk	An estimate of the probability of a hazard occurring.
Sanitation	Removal of soil and debris and the destruction of micro-organisms.
Sanitiser	A chemical that combines a detergent with a disinfectant to clean as well as kill micro-organisms.
Slurry	Liquid mixture of farm animal urine and faeces.
Supply chain	Description of the operations involved in growing fresh produce on the farm and supplying it to the consumer. Surface water Rivers, lakes, ponds etc. where the water source is open to the environment.
Surface water	Rivers, lakes, ponds etc. where the water source is open to the environment.

Chapter 1 : General Hazard Control

1.1 Water

• Hazard Identification

Water is essential in agriculture for pre-harvest irrigation, application of chemicals and for post-harvest rinsing/washing, cooling and transport. The quality of water affects the safety of produce. Contaminated water can directly contaminate produce and/or enable contamination to spread in the field or factory.

• Microbiological Hazards

Microbiological hazards associated with water include pathogenic bacteria, viruses and some species of protozoa. Significant pathogenic bacteria include toxic strains of *Escherichia coli* (e.g. *E. coli* O157), *Salmonella* spp., *Vibrio cholerae* and *Shigella* spp. Viruses include Small Round Structured Viruses (SRSV or Norwalk) and Hepatitis A. Pathogenic protozoa include *Cryptosporidium parvum, Giardia lamblia* and *Cyclospora cayetanesis*.

Microbiological hazards arise from human and animal waste that contaminates a water supply used during the growth or processing of produce. The extent of this hazard is unknown but research has demonstrated the relationship between the increased detection of pathogenic bacteria and the use of contaminated irrigation water[6,7]. In addition, food poisoning outbreaks concerning some fruit and vegetables have been linked with contaminated water used in packing facilities[8].

• Chemical Hazards

Water-borne chemical hazards that arise on the farm are generally due to the use of water supplies contaminated with agricultural pollutants or industrial pollutants. The main water-borne chemical contaminants are nitrates/nitrites and degradation products of pesticides and heavy metals. Fruit and vegetables tend to concentrate chemical contaminants that they are exposed to in irrigation water and this may lead to chemical concentrations higher than safety limits allow.

The production of winter crop lettuce and spinach can lead to the accumulation of high levels of nitrate/nitrite in the leaves. This problem is caused by high levels of nitrogen in the soil, excess fertiliser use, together with poor light conditions. A voluntary code of practice outlining best use of fertilisers can be obtained from Teagasc.

Chemical contamination that can occur in processing water may include any of the above chemicals if the source of water is not potable. However additional contamination can result from inadvertent or mis-use of cleaning chemicals, such as peracetic acid based disinfectants, caustic based cleaners or detergents without effective rinsing to remove residues from the processing equipment.

• Hazard Control

Producers and processors should note that most fruit and many salad crops can be eaten without further washing or cooking by the consumer. All steps should be taken during production and processing to ensure that these crops are free from pathogenic micro-organisms. Careful use of clean water is very important.

Operators should consider the following issues and practices when assessing water quality and applying controls to minimise hazards. Practices should be selected and combined as appropriate to an operation and the quality of the water supply.

• Agricultural Water (Water used during production of produce)

To minimise the risk of contaminated fruit and vegetables it is important to minimise the contamination of the water used on the crop.

Supply Chain steps covered by this section include:

- Sowing and Propagation
- Preparation of soil
- Transplanting
- Growing.

Typical sources of agricultural water are rivers, streams, irrigation ditches, ponds, lakes, groundwater from wells and municipal supplies. Agricultural water will vary in quality but this must be controlled where possible. In general the risk of contamination is greatest for surface water supplies, less for ground water supplies and significantly less for municipal water supplies. Ground water supplies are at an increased risk of contamination from surface water if the well lining is cracked.

- **Water quality:**

  Surface water can be contaminated by many practices and only some will be under the control of the grower. Decisions regarding irrigation practices can be made after an assessment of the risk of contamination resulting from practices that impinge on a shared water supply. Growers should consider these risks:

  - The prevalence of livestock in the region of the water supply, including a consideration of practices on any other farms accessing a shared water supply (e.g. a river)
  - The prevalence of arable/horticultural farming in the region of the water supply
  - The prevalence of industry discharging effluent into the shared water supply
  - The application of manure/cattle slurry to the land by many farms in the region

- Local rainfall patterns and land topography that may increase the likelihood of contaminating runoff from these farms
- Controls in place by the authorities to monitor and minimise the risk of shared water contamination
- Usage of land in adjacent farms that may inadvertently contaminate the crop.

Growers should prevent the contamination of the farm water supply that may result from their own poor agricultural practices.This is particularly important when captured surface water supplies such as ponds are used. Consideration should be given to the following:

- If ground water is used then the structure of the well must be in good condition to minimise the risk of contamination from surface water supplies.
- Shallow wells are more prone to the influence of surface water than deep wells and should therefore be monitored more frequently.
- Septic tanks near a well can be a particular source of concern. Poorly designed, maintained or positioned septic tanks can contaminate the soil and lead to contamination of the ground water, especially when rainfall is high. Growers should evaluate this risk and take steps to ensure septic tanks are moved and functioning correctly where appropriate.
- Manure/slurry stored adjacent to growing areas can run off into the growing area and contaminate the crop especially in periods of high rainfall.
- Leaking or overflowing slurry tanks or manure lagoons may result in contamination of the surface water supply or the crop directly.
- Livestock with uncontrolled access to wells, surface water or pump areas may contaminate the water supply with their faeces.
- Containers with chemicals may leak if they are damaged, left open, stored or disposed of incorrectly. This may result in contamination of the water supply. Consider safe storage of chemicals, for example store them in a covered area, where they cannot be damaged by farm machinery etc. Dispose of used containers in an appropriate manner, in accordance with Bord Glas guidelines.
- Chemicals sprayed on crops may contaminate the water supply, especially when rainfall is high. Ensure that best practice procedures such as those recommended by Teagasc are followed at all times to prevent this.

- **Irrigation practices:**
  Growers should concentrate on maintaining and protecting water quality. However, if a high standard of water quality cannot be ensured then changes in irrigation practices can help to minimise the risk of contaminating the crop. Scientific trials have shown that when contaminated water is in contact with the edible portion of plants, the risk of the plant being contaminated increases. Growers with poor quality water that cannot be controlled should consider irrigation practices that minimise the contact of water with the edible portion of the plant. Low volume sprays, drip, furrow or underground irrigation are all options that can be adopted if appropriate. For root crops or low growing crops, it may not be possible to minimise water contact in these ways.

- **Water testing:**
  Testing of agricultural water for micro-organisms and chemicals, whilst important should not be used as the sole method of controlling water-borne hazards.

  Water testing results can vary considerably and only reflect the water quality at the time of sampling. Testing methods for protozoa such as *Cryptosporidium* are not common. A new rapid test is available (contact Bord Glas for details). Growers should focus on the adoption of good agricultural practices to control water-borne hazards and use water testing as a means of validating these practices.

  Where water comes from a public supply information on its quality should be available from the local authority. Growers should consult the Environmental Protection Agency for advice on testing water. Testing programmes will vary depending on the sources of water used.

  Simple bacterial tests for faecal contamination will only give an approximation of the quality of the water supply. It will not give an indication of the presence of pathogenic bacteria, viruses or protozoa although there would be an increased risk of these contaminants if the faecal pollution is high. Microbiological testing alone would give no indication of the levels of chemical contaminants. Here, testing would only be advisable if a specific contaminant was suspected as a result of a related incident of chemical discharge/runoff.

• Processing Water

To minimise the risk of contaminated fruit and vegetables, it is important to minimise the contamination of the water used during post harvest handling steps. Water of drinking quality (Potable water) is recommended for all processing water. The European Communities (Quality of Water Intended for Human Consumption) Regulations 1988 specify the requirements for drinking water. It is essential that potable water is used for the final rinse stage of any post-harvest handling process.

Supply Chain steps covered by this section:

- Packing and grading (in some on-farm operations)
- Packing and grading (off farm)
- Primary processing.

Post-harvest handling of fruit and vegetables involves a high degree of produce-to-water contact. Water can reduce contamination, spread contamination or contaminate the produce itself depending on how it is managed. Root crops bring a lot of soil into the processing environment and need washing with several changes of water. Salad crops with minimal soil adhesion may present a greater risk because they may not be cooked before consumption.

- **Water quality:**

  Water quality will vary throughout the stages of the post-harvest process. For example high quality water is required for a final rinse before packing but may be of lower quality in a dump tank at the start of the process where soil, washed from produce, quickly mixes with the water. The following points should be considered to maintain the quality of processing water:

  - Changing water frequently for fresh potable water reduces the chance of contaminating produce. Consider developing written standard operation procedures that include water change schedules for all steps in the process.
  - Dirty equipment can re-contaminate clean water and therefore equipment needs to be cleaned and sanitised. Dump tanks, flumes, wash tanks and hydrocoolers need particular attention. Consider developing written cleaning schedules for all equipment including frequency, cleaning practice and post-cleaning hygiene inspection.
  - High quality water can be contaminated by back-flow from contaminated water in lines and tanks. This should be prevented by installing back-flow devices.

- Poorly maintained and malfunctioning equipment designed to maintain water quality may allow contamination of the water supply. Examples are, filters, UV sanitisers, chlorine dose pumps and back-flow prevention devices. Consider developing written standard operation procedures to cover a preventive maintenance schedule for important equipment such as those outlined above.
- Water should flow counter current to the produce flow. This ensures that produce nearer the packing process is washed with the cleanest water. Filters should be fitted to equipment to ensure debris is removed from circulating water.

- **Wash water**

Washing produce reduces the chances of micro-organisms and chemicals remaining on the surface. This is an essential step since most contaminants are on the surface of fruit and vegetables and can also contaminate surrounding produce, thus spreading the hazard. Most post-harvest processes involve a considerable degree of water to surface contact, for example in dump tanks, flumes and hydrocoolers. The following points should be considered:

- The washing process must be sufficient to remove soil, chemicals, micro-organisms and foreign bodies.
- If the produce is not subject to bruising, then vigorous washing increases the chances of removing the microbiological or chemical hazard. Surface scrubbing using brushes is even more effective but only if the brushes are regularly cleaned and sanitised.
- A series of washes is more effective than a single wash if the produce is washed with fresh clean water each time. This prevents the build up of micro-organisms and washed-off chemicals in the wash water. A process that continually re-cycles dirty water through its process steps will increase the likelihood of chemicals remaining on, and micro-organisms surviving on the surface of equipment and the produce.
- Wash water should be maintained below 10°C to reduce the growth rate of micro-organisms that are washed off the fresh produce. This is important if water is not replaced frequently with clean water. This will also increase product quality by removing field heat. However, consider the following information before adopting this practice:

– Some produce items that have a high water content (e.g. apples, celery and tomatoes) are susceptible to micro-organisms entering the skin via the stomata. Internalisation of potential pathogens or chemicals is a problem because surface washing will not remove them. With these crops, if the temperature of the wash water is less than the temperature of the produce, the temperature differential can force water into the fruit or vegetable. If this water is contaminated then the produce may become contaminated on the inside. The World Health Organisation recommend that with these types of produce the wash water should be maintained 10°C above the temperature of the produce.[3]

Therefore, it is recommended that for whole produce with high water content, that may be prone to internalisation of micro-organisms, the pre-washing step for the bulk removal of soil should be undertaken in water 10°C above the temperature of the produce if possible. Subsequent washing steps should be carried out in cold water to remove field heat and maintain quality. Wash water must be renewed frequently to prevent a build up of micro-organisms and preferably be treated with an effective antibacterial water treatment, such as chlorine with frequent monitoring to ensure effective concentrations are maintained. For these types of produce, spray washing would be better at this stage than a dump tank provided that the water, if re-circulated, is filtered and treated to prevent the build up of micro-organisms and periodically replaced to prevent the build up of any chemicals washed off the produce. (Elevated temperature water does not need to be used for low water content produce like carrots and potatoes because they are not as prone to water being drawn into their internal structure).

- The inclusion of a decontamination step to destroy micro-organisms should be considered where appropriate. It is especially important where the quality of water cannot be guaranteed or when produce items are intended to be eaten without further cooking. However, consider the following information before adopting this practice:

  – A decontamination step may only be effective if produce is pre-washed in potable water to remove as much soil as possible before decontamination. This ensures that the decontamination step, using water treated with an antibacterial treatment like chlorine, remains effective. Organic matter inactivates chlorine.

– The concentrations of disinfectant used in the wash process must be monitored frequently in the wash water because they will reduce with time depending on the organic content of the water, its temperature and dilution rate. Disinfectant should be carefully dosed into the water to ensure that the concentration is optimal without being in excess. This is especially important in circulated water. An automated disinfectant monitoring and dosing system is recommended.

– If a decontamination step is used then it must be followed by a rinse step in potable water to remove any disinfectant by-products (e.g. trihalomethanes, that are harmful and are a by-product of the use of chlorine).

– Refer to **Antibacterial chemical water treatments** section below

- Where possible, a water removal step should be used to remove excess moisture. However, water should be removed gently to prevent damage to the produce. Dry produce is less likely to become re-contaminated.

- **Antibacterial chemical water treatments**

If antibacterial chemical water treatments are used it is recommended that, where possible, an automated chemical monitoring and dosing machine is employed for optimum control of the process. These machines are available for chlorine but may not be available for other chemicals.

There are many chemical treatments that are applied to water, for example water softening treatments, flocculation treatments and decontamination treatments. This section contains information on chemical treatments used to kill micro-organisms in water and on the produce in contact with water. This approach should never be substituted for practices which ensure that high quality process water is used throughout post-harvest handling activities. However, the use of antibacterial chemicals can enhance the safety of an operation adhering to good hygienic practices.

Chemical treatments are not only used to decontaminate water but are used to decontaminate the surfaces of processing equipment and the surfaces of the fruit and vegetables being processed. The effectiveness of chemical water treatments in decontaminating the surface of fruits and vegetables depends upon the geometry of the surface of the produce, the ability of the chemical to 'wet' the surface, the contact time and the environmental conditions (temperature, pH etc.). Consider the following information before adopting this practice:

• Chlorine: Liquid chlorine and hypochlorites are moderately effective for decontaminating surfaces of processing equipment, water itself and surfaces of the produce being processed. The term 'free available chlorine' encompasses a number of effective forms of chlorine, however, it is hypochlorous acid that is the most effective antibacterial chemical form in the contact time available. Commonly used concentrations of free available chlorine are 50-100ppm (0.05g/l – 0.1g/l) with a contact time of 1-2 minutes. Free available chlorine does not mean total chlorine since this is a measure of the free and combined chlorine. Combined chlorine is unavailable for decontamination and therefore, it is the free chlorine concentration that is important.

A pH of 6.0-7.5 is the most effective pH for chlorine decontamination. A lower pH favours the production of more hyperchlorous acid and hence favours decontamination. Lower pH's also promote corrosion of steel in the presence of chlorine. Toxic chlorine gas is produced below pH 4 and this must be avoided. It is recommended that the pH of the treated water is monitored and corrected using citric acid to lower pH and sodium hydroxide to raise pH. Monitoring and control is best carried out with a pH probe and automatic doser. PH paper can be a quick test but is less effective.

Generally at a given pH the lower the temperature of the water, the more hypochlorous acid is formed and therefore low temperatures are favourable. Chlorine rapidly loses its activity on contact with organic matter or exposure to air, light and metals. Chlorinated water that is dirty from contact with washed produce is unlikely to kill micro-organisms. The free chlorine concentration should be measured at least once an hour. Test kits are available to check free chlorine levels and these should be used at regular intervals to ensure the effectiveness of the decontamination treatment. For effective measurement an amperometric hypochlorous acid sensor is recommended.[9]

Bacteria in cracks, crevices, pockets and natural openings in the skin of produce are inaccessible to chlorine. Hence fresh produce should be handled in such a way as to minimise damage. Waxy cuticles on some fruit and vegetables repel water and the fine hairs on others prevent water from reaching surfaces. Surface active agents (wetting agents) that can surmount this problem have been tested, but can tend to cause a reduction in the quality of the fresh produce.

• Organic acids: The most common organic acids are lactic, acetic, citric, succinic, malic, tartaric, benzoic, propanoic and sorbic acids. They can either kill bacteria or stop the growth of bacteria but without killing them. Organic acids affect fungi and bacteria primarily, there is little data on their effect on protazoa. Organic acid washes or sprays have been used with success in the meat industry to decontaminate carcases, but their application to fruit and vegetables has been limited. Laboratory based trials have demonstrated the effectiveness of certain treatments but wide scale use has yet to appear. Hence data in real processing situations is limited.

• Proprietary washes: Certain combinations of chemical disinfectants can be purchased as proprietary brands. Fresh produce wash (Driwite Ltd.) contains a mixture of sucrose esters, sodium citrate, glutamate and glycerine, combining antibacterial agents with wetting agents for maximum surface contact. There is little data available to evaluate these chemicals.

• Other chemical antimicrobials: Many other chemicals have been tested for their antimicrobial ability but few if any are used extensively in Ireland. Briefly these include

– **Ozone** – good broad range activity but can reduce sensory quality and is unstable requiring generation on site. Can cause corrosion of metal process equipment.

– **Chlorine dioxide** – similar to chlorine but unstable and needs generating on site. It has the advantage of not being inactivated by organic matter and it is not dependent on pH for activity.

– **Hydrogen peroxide** – has GRAS (generally recognised as safe) status in the USA and is effective against a range of micro-organisms. Its activity depends on temperature, pH and other environmental factors.

– **Quaternery ammonium compounds** – used extensively as surface active agents in the food industry on equipment and structures, but not really tested on produce.

– **Trisodium phosphate** – effective in removing Salmonella from poultry but largely untested on produce.

– **Iodine/bromine** – similar to chlorine but of limited use in disinfection of produce.

- **Cooling**

  Produce is best harvested during the cool of the morning to prevent the build up of field heat that must then be removed by the cooling process. Cooling water is a potential source of contamination of fruit and vegetables if it is managed incorrectly. The following points should be considered:

  - Good quality produce that is intact is more likely to resist contamination from micro-organisms and prevent chemicals moving from the surface to the internal tissue. Therefore maintaining temperatures that promote optimum product quality may reduce the risk of contamination.

  - The use of antimicrobial treatments in the cooling water will reduce the risk of contamination with micro-organisms, as will frequent water changes with clean, drinking quality water. This is especially important in hydrocoolers. Low density produce and cut produce with open surfaces should be clean before cooling to prevent the internalisation of micro-organisms caused by an adverse produce-water temperature gradient (see section on Wash water).

  - Chilling equipment should be cleaned and decontaminated frequently to ensure that micro-organisms do not build up and contaminate the cooling water.

  - If produce is especially prone to contamination either by virtue of its structure or by virtue of the process it has been subjected to (e.g. shredding), air-cooling may be an alternative to water cooling. This eliminates the risks associated with contaminated water.

  - Air-cooling facilities must be clean and sanitary and the cool air must be free from microbiological contaminants.

- **Validation of the washing process**

  The effectiveness of the post-harvest washing process should be validated, to ensure it is capable of removing the microbiological and chemical contamination on the range of produce it encounters under operating conditions. It is important to know the levels of contaminants on produce entering the process, the levels of contaminants on produce leaving the process and the steps in the process that are critical for the reduction of the hazards and how they are controlled.

1.2 Farmyard Manure, Compost and Faecal Material (Biosolids)

• Hazard Identification

Properly treated manure can be an effective and safe fertiliser. However, untreated, improperly treated, or re-contaminated manure, animal slurry and other faecal material (e.g. septic tanks) may contain micro-organisms that are harmful to human health (pathogens) and have the potential to contaminate fresh produce. This contamination may be direct (in the form of applying contaminated manure) or indirect (in the mis-management of sources of faecal material on the farm, which may then enter the ground or surface water through runoff, ultimately contaminating the field of crops – see section on Microbiological Hazards).

Crops in, or near the ground, are most vulnerable to pathogenic micro-organisms which may survive in the soil. Low growing crops that may be splashed with soil during irrigation or heavy rainfall are also at risk.

• Microbiological Hazards

Animal manure and faecal material (human or animal) are a significant source of human pathogens. Of particular concern is the recently discovered bacterial pathogen *E. coli* O157. Healthy cattle and other ruminants are the main source of this pathogen, which they excrete periodically in their faeces. Studies have shown that *E. coli* O157 can survive in the environment, animal faeces and soil for extended periods of time (i.e. several months). Other animals including pigs, horses, cats, birds and rodents may also carry and excrete *E. coli* O157. In addition to *E. coli* O157, animal and human faeces are known to harbour a range of other pathogens, including bacteria (eg *Salmonella* spp.), viruses (e.g. *Hepatitis* A) and protozoa (e.g. *Cryptosporidium parvum*).

• Chemical Hazards

Chemical Hazards that have been raised as issues include potentially toxic heavy metals and organic compounds.

• Hazard Control

The animal intestines of livestock are a source of pathogenic bacteria. Many pathogenic bacteria are passed to humans via products of animal origin. Often this is a direct result of faecal contamination. It should be assumed that faecal material from animals contains pathogenic micro-organisms and therefore steps must be taken to eliminate the risk of transfer to fresh produce. This is of particular importance in organic farming or when using farm-yard manure to force crops, e.g. rhubarb.

Supply chain steps covered by this section:

- Soil/Ground Preparation
- Sowing & Propagation
- Growing.

• Farmyard Manure (FYM)

Manure should always be treated to ensure the reduction or elimination of pathogens. Treatment may be divided into two types, passive and active.

- Passive treatment relies primarily on the passage of time, in conjunction with environmental factors, such as temperature and moisture fluctuations and ultraviolet irradiation, to reduce pathogens. However, farmyard manure should at least be partially rotten before application to the soil. It should then be ploughed in and not left on the surface of the soil. It is not recommended that raw farmyard manure or slurry be used in horticulture. FYM should be given time to break down in the soil. Therefore, sowing should be delayed to allow for breakdown of organic matter.

- Active treatments include pasteurisation, heat drying, anaerobic digestion, alkali stabilisation, aerobic digestion or combinations of these. Composting is a commonly used active treatment in which organic materials are digested, aerobically or anaerobically, by microbial action. When composting is carefully controlled and managed, and appropriate conditions are achieved, the high temperature generated can kill most pathogens in a number of days. Generally it is recommended that the manure heap is maintained for at least three months (see the standards of Organic Trust Ltd, IOFGA and Demeter Ltd.).

- **Storage, containment, recontamination**

  Growers should consider the following issues relating to storage, containment and recontamination of farmyard manure:

  - Manure storage and treatment sites should be situated as far as is practical from fresh produce production and handling areas. The minimum distance will depend on such factors as farm layout and slope of the land, what runoff controls are in place, the likelihood of spread by wind or heavy rainfall and the quantity of manure and how it is contained.

- Where run off, leaching, or wind-spread is a concern, barriers or physical containment should be considered. Storage on concrete slabs or in clay lined lagoons may reduce the potential for leachate to enter the groundwater.

- Covering manure heaps will protect them from rainfall that could result in leachate. Alternatively, growers may consider collecting water that leaches through the manure. Growers reusing this manure leachate should follow the practices outlined for 'use of farmyard manure' (see below).

- Equipment, such as tractors and trailers, that come into contact with untreated or partially treated manure and are then used in produce fields, can be a source of contamination. Equipment used to turn compost and other multiple use equipment that contacts manure, should be cleaned (such as with high pressure water or steam sprays) before it contacts fresh produce. Growers should be aware of other factors, such as farm layout and traffic flow, that may allow a tractor to drive through manure before entering a produce field.

- **Use of farmyard manure**

  - The treatment of manure is not an exact science and there is a chance that some pathogens may survive. The risk of contaminating fresh produce can be minimised further by maximising the interval between manure application and produce harvest

  - Growers purchasing manure should take account of the source and the treatment that it may have undergone before use

  - Growers should contact Teagasc for advice specific to their individual operations and regions.

- **Use of untreated farmyard manure**

  Untreated manure or leachate from raw manure or animal slurry should NOT be used on produce fields after the crop is sown.

  In addition to the general advice given on the use of farmyard manure, the following recommendations are important if the use of untreated or 'raw' manure is being considered.

- It is not recommended that raw farmyard manure or slurry be used in horticulture. If its use is unavoidable, raw manure should only be applied for ground preparation purposes and should be at least partially rotten.

- Raw manure should be mixed into the soil rather than being spread on the surface so that pathogens are reduced and the risk of run-off into a water source is avoided.

• Biosolids

Biosolids are the organic by-product of urban wastewater treatment, which once treated to an approved standard, may be used as a fertiliser/soil conditioner in agriculture. Council Directive 91/271/EEC concerning urban wastewater treatment requires treatment of wastewater discharging from all major population centres by 31 December, 2005 and placed a ban on disposal of sludge to sea from 31 December, 1998. The Directive further encourages reuse of wastewater sludge wherever appropriate. While the use of biosolids on fruit and vegetables is discouraged, the Code of Practice being prepared by the Department of the Environment and Local Government will address the safety issues and outline safe use of biosolids on fresh produce. A Euregap Code of Practice for Retailers Standard Quality of Fruit and Vegetables also outlines safety with respect to biosolids.

• Animal Dung

While it is not possible to exclude all animal life from fresh produce production areas, measures should be taken to restrict animal access in so far as possible. Growers should consider:

- The prevalence and likelihood of significant amounts of uncontrolled deposits of animal dung coming into contact with crops
- Measures to exclude where possible, animals from fresh produce fields during the growing season
- Measures to ensure that animal waste from adjacent fields or waste storage facilities does not contaminate fresh produce.

1.3 Hygienic Practice

All processors involved in fresh produce operations after the farm gate are bound by law to adhere to Council Directive 93/43/EEC on the Hygiene of Foodstuffs. This was transposed into Irish law in April 1998 in SI No.165 of 2000 European Communities (Hygiene of Foodstuffs) Regulations, 2000. There are three practical guides to compliance with these regulations and these are I.S. 341 : 1998 (Hygiene in Food Retailing and Wholesaling), I.S. 342 : 1997 (Guide to Good Hygienic Practice for the Food Processing Industry in accordance with Council Directive 93/43/EEC on the Hygiene of Foodstuffs) and I.S. 343 : 2000 (Food Safety Management incorporating Hazard Analysis and Critical Control Points).

Anyone involved in the post-harvest handling of produce should be familiar with the legislation as listed and should follow the Irish standards which can be obtained from the National Standards Authority of Ireland. This section will only deal with general hygiene concepts and is not a substitute for complete familiarity with the legislation and national standards. Further information on legislation and hygiene are outlined in the Bord Glas quality manuals and these should also be consulted.

• Hazard Identification

Produce that is clean and free from pathogenic micro-organisms and chemical contaminants when harvested, can easily be re-contaminated if it is not handled hygienically (during the process that ultimately ends with the consumer). Produce can be contaminated by unhygienic equipment and the unhygienic practices of the personnel involved in the process. High standards of hygiene will minimise the risk of produce re-contamination.

• Microbiological Hazard

Pathogenic micro-organisms can re-contaminate produce in two main ways either via poorly cleaned equipment and unhygienically operated processes, or via workers. Workers who are suffering from food poisoning generally excrete the pathogenic micro-organisms that have caused the illness, in large numbers and for a significant time-span after recovery. In addition, workers with open sores, boils or open wounds are also a source of disease-causing micro-organisms. Workers can therefore inadvertently contaminate process water, the produce itself, processing equipment and other workers.

• Chemical Hazards

In the context of hygienic practice, chemical hazards may generally arise from incorrect use of sanitation chemicals, incorrect cleaning procedures and leakages from equipment. In the case of chemicals leaking from equipment, typical hazards might be leakage of coolant from refrigeration equipment and leakage of non-food grade lubricants from equipment bearings, motors and other movable machinery. Hygienic practice applied in this situation includes preventive maintenance of equipment, maintenance of records of cleaning procedures and equipment maintenance and adequate training of staff involved in the sanitation and maintenance functions.

• Hazard Control

Hygienic practice is essential at all steps in the fresh produce supply chain. Food safety incidents will be minimised if a hygienically designed premises and process is maintained.This philosophy underpins a well-managed Hazard and Critical Control Point (HACCP) system.

• Workers Health and Hygiene

"Staff have a legal responsibility not to work in areas where food is exposed if suffering from a persistent cough, diarrhoea or vomiting; infections of the mouth, throat, nose, eyes and ears; infectious skin disorders on their face, hands or forearms; or if they suspect they are suffering from hepatitis, typhoid or paratyphoid." (I.S. 342; 1997).

Supply Chain steps covered by this section:

- Harvest
- Post-harvest handling
- Packing/grading
- Storage on the farm
- Transport on and off the farm
- Processing
- Retail

All workers involved in handling produce and also those workers indirectly involved (truck drivers, pest control personnel, buyers, equipment operators etc.) must be aware of basic hygienic practice. Food handlers involved in harvesting can contaminate fresh produce as easily as those food handlers involved in further processing activities. This is especially important for crops such as fruit, scallions, leeks and lettuce that involve labour intensive harvesting and produce handling. The key controls for all food handlers are discussed below.

- **Workers health**

Many communicable diseases and infections can be transmitted by infected workers through food and food equipment. Identification of infected employees is important in identifying and controlling the risk. The following is a list of the most likely symptoms exhibited by infected people:

• Hepatitus A virus	Fever, jaundice
• *Salmonella typhi*	Fever
• *Shigella* species	Diarrhoea, fever, vomiting
• Norwalk virus (SRS virus)	Diarrhoea, fever, vomiting
• *Staphylococcus aureus*	Diarrhoea, vomiting
• *Streptococcus pyogenes*	Fever, sore throat with fever
• *Salmonella species*	Diarrhoea, fever, vomiting
• *E. coli* O157	Bloody diarrhoea, cramps

Diarrhoea, vomiting and fever are also symptoms of several other pathogens and should be taken as an indication of possible infection. The following actions should be considered:

- Before commencing employment all new staff including temporary staff, should complete a medical questionnaire or be passed as fit to work with food by a doctor.
- Workers who display symptoms of infectious disease should be excluded from direct and indirect contact with produce that may require exclusion from the work place depending on the type of premises (legal requirement S.I. 86 of 1998).
- The employee should consult a doctor who will advise when work can be resumed.
- Workers should be encouraged to report all illness to their supervisor before commencing work and the supervisor should be aware of the symptoms of infectious diseases so that appropriate steps can be taken.

Boils, open wounds and sores may contain micro-organisms that can infect the produce. The following steps are necessary:

- Cover all wounds, sores or boils with a sterile disposable or washable dressing. Plasters should be coloured and contain a metallic strip for easy identification should they become detached and fall into the produce.

- Where wounds cannot be covered the worker should be excluded from direct contact with the produce and equipment or water that contacts the produce.

- **Hygiene and training**

Under the hygiene of foodstuffs regulations it is a legal requirement that 'The proprietor of a food business shall ensure that food handlers are supervised and instructed and/or trained in food hygiene matters commensurate with their work activity'.

Employee hygiene training and control starts with the management. Company management is responsible for providing and maintaining a safe and clean working environment, safe equipment and tools, establishing and enforcing work rules and employee conduct and establishing and implementing a continuing education programme to promote safe and hygienic work habits. Once the processing plant and equipment comply with a good manufacturing process, employees must abide by good personal hygiene practices to ensure a product that is safe for human consumption. Since employee handling can introduce pathogenic contamination of prepared produce, management must adopt and enforce specific requirements.

The degree of implementation of the following measures is dependent on detailed risk assessment related to the production process. Food handlers should be instructed in the causes and prevention of food poisoning, the relationship between micro-organisms and food poisoning and be made aware of the following general aspects of personal hygiene, in addition to any specific concerns determined by their role in production.

- Employees should wear clean, properly designed outer garments, into which they change before entering production areas. These outer garments should be loose fitting, without pockets and without dangling or hanging attachments. A daily change of work wear from a reputable laundry/linen service company is highly recommended.

- Regular (daily) showering or bathing is encouraged.

- Hands should be washed and sanitised on various occasions:
  - Before starting work each day on entering the production area
  - After visiting toilet facilities or blowing nose
  - After any absence or break from the workstation
  - After handling dirty raw materials or performing any maintenance service
  - After picking objects up off the floor.
- Any jewellery, with the exception of plain wedding bands, should be removed before entering the process area.
- A hat/hairnet covering all hair should be worn before entering processing areas. Similarly a beard snood should be worn to prevent facial hair falling into product.
- Eating food, chewing gum or sweets or consuming drinks of any sort, should not be permitted in the processing area at any time.
- White coats, beard snoods, hairnets, production footwear etc. should be removed and stored on a rack before entering a toilet, canteen or other area where contamination could occur.
- Personal hand tools, knives etc. should be washed and sterilised according to hand washing procedures, then hung on racks in a suitable case.
- Sanitising hand dip stations should be maintained at the entrance to production areas. These stations should contain a properly formulated and controlled solution.
- Suitable shoes or rubber boots are required for the processing area. These boots must not be worn outside the building and should be cleaned and sterilised each time the employee leaves a processing area.
- Coats and other personal items should be stored in lockers located in changing rooms.

- Management should ensure that supervisors and responsible production operatives receive continuing ongoing training and education in proper personal sanitation practices. Company management has a responsibility to ensure such senior staff has the competency, education and experience to identify and promote good hygiene practice.

- Hygiene training sessions should be conducted for all food handlers.

- Procedures should be put in place to ensure compliance with hygiene requirements. If a foreign workforce is employed then multi-lingual instructions should be posted on walls in changing areas and hygienic procedures communicated and understood.

• Toilet Facilities and Handwashing Stations

These facilities must be provided in any area where post-harvest handling of produce is undertaken. This applies to seasonal in-field produce picking, packing and grading facilities as well as in off farm warehouses, production plants and retail outlets. The following points should be observed:

- **Toilet facility construction:** Whether permanent or portable, toilets must be constructed, sited and managed so that human waste does not enter the soil or water being used to grow or process the crop.

- **Toilet facility accessibility:** Accessibility will determine use. Workers should have access to toilets at any time to encourage their use. This is especially important on the farm where accessible toilets will reduce the incidents of workers relieving themselves in the fields where crops are growing or could be subsequently planted. In processing, storage and retail facilities, toilets must not be sited directly off the food handling area.

- **Toilet maintenance:** Toilet facilities should be maintained in good clean working order. This will encourage workers to use the facilities provided.

- **Handwashing facilities:** These must be provided and located next to toilets to remind workers to wash their hands after going to the toilet.

The facility should be supplied with water, a basin, non-perfumed anti-bacterial soap, disposable paper towels and a waste container.

• Harvest Hygiene

Good hygienic practice when fresh produce is being harvested will ensure that produce is not contaminated by contact with soil, water, fertiliser, workers or contaminated harvesting equipment. This is particularly important for fruit and salad crops that may not be washed or cooked by the consumer

The hazards associated with water and their control is dealt with in the section on **Water**. The hazards associated with manure and their control is dealt with in **Workers Health and Hygiene**. The hazards associated with worker hygiene and their control is dealt with in **Workers Health and Hygiene**. These additional points should be observed:

- Harvest storage facilities should be cleaned before use and disinfected if necessary. If pest activity is evident then measures should be taken to remove and exclude them.
- Produce containers that are damaged or unable to be cleaned should be discarded. All other containers should be cleaned thoroughly before use. During use, containers should be re-cleaned between loads if possible.
- If produce is washed and cooled in the field then ensure it is not contaminated, see section on **Processing Water** and the section on **Workers Health and Hygiene**.
- As much soil and mud as possible should be removed from the produce before it leaves the field. This may not always be practical in wet conditions.
- Do not use farm equipment which may be used to transport rubbish and manure to transport produce. Ensure that produce containers do not come into contact with such equipment.
- Ensure someone on the farm has responsibility for ensuring that equipment and containers are used correctly and cleaned appropriately, otherwise this important practice is likely to be overlooked.

• Processing Facility Hygiene

Processing facilities with poor hygienic design and practices can contribute to significant contamination of fresh produce. Care must be taken to ensure that fresh produce items are not contaminated by wash water, process equipment or workers. Poor practice can easily distribute contamination from a few produce items to the rest of the produce being processed.

Processing facilities include packing and grading houses, storage facilities, secondary processing facilities (pre-prepared vegetable producers etc.), central distribution/wholesale outlets and retail outlets.

Careful attention must be given to the layout, design and construction of processing operations.

- Process flow must ensure that produce moves through the facility from input, where there can be high levels of contamination, to output, where there should be lower levels of contamination. Contamination from earlier steps in the process must not be allowed to enter later steps in the process due to poor plant layout.

- Floors must be easily cleaned, durable, not subject to slippage and very hard wearing. Some produce items such as onions contain acids, which through time, will have a very detrimental effect on the standard of poor grade flooring. Better quality premises will have a floor that is sloped, coved to walls, fitted with drains and finished with a material which will withstand very aggressive wear and tear.

- Careful consideration should be given to drainage design so that in all instances the drained water will flow opposite to the direction of product flow.

- Walls and ceilings must be constructed of an acceptable food grade material that is washable and impervious so that bacteria are not harboured in seals, seams or cracks. If a room in the facility is refrigerated then the walls should be clad with insulation panels suitable for use in food preparation areas.

- A realistic and rigidly applied cleaning schedule must be implemented and its efficiency tested on a regular basis. This cleaning efficiency can best be established by swabbing with any of several new quick result test kits currently on the market.

Processing facilities with poor hygiene can contribute to significant contamination of produce. Micro-organisms from dirty floors, drains and equipment surfaces can be transferred to produce. Usually the micro-organisms have been under ideal growth conditions and therefore their numbers can be very high so that even small amounts of dirt contacting produce can cause widespread contamination. Good hygienic practice must be observed and these should also include the following:

- Removal of soil and mud should be undertaken outside the facility as much as practically possible to reduce the build up of dirt within the facility.

- Containers for packed produce should be clean and in good repair.

- Containers used for ready-to-eat fresh produce should be disinfected after cleaning whilst ensuring that the method of disinfection does not cause chemical contamination of the produce.

- Containers and packaging material should be stored in a clean, dry place away from potential contact with pests, soil and manure or water condensation from overhead structures/equipment.

- Equipment used in the processing facility must be of a design that facilitates adequate cleaning.

- Equipment must be cleaned at least daily. Mud, soil and produce debris should be removed from equipment washed with a detergent and rinsed before a final wash with a chemical disinfectant and a thorough rinse in water of drinking quality.

- Workers involved in cleaning should receive adequate instruction and training to ensure correct usage of chemicals and effective sanitation of the equipment.

- Ancillary equipment such as knives, blades, boots and protective clothing should also be cleaned and disinfected at the end of each day. All tables used in processing areas should be made from stainless steel, with stainless steel legs and frame. The use of wooden topped tables is not acceptable due to the difficulty with thorough cleaning of surfaces. Bins should be plastic or stainless steel or of another such material that will not easily rust, chip or fracture to either contaminate the food or harbour micro-organisms. A log should be kept of ancillary equipment and breakage's should be accounted for and noted in the log together with preventative actions taken to ensure that produce is not contaminated by metal etc. Glass should not be used anywhere in the production area.

- If cooling equipment is being used, ensure it is cleaned and disinfected at the end of the day and inspected for leaks and damage. If a leak is identified then do not distribute the product packed since the last clear inspection of the equipment, because it could be chemically contaminated.

- The facility must have a pest control system. Rodents, insects and birds spread disease and increase the risk of produce contamination. Ensure that areas of the facility do not encourage infestation and if there are potential access routes, nesting sites, food or water, take action to eliminate them as much as possible. Install fly-screens or electric insect controllers (insectocuters) and arrange a regular managed pest control programme. Keep a pest control log to ensure the control programme is being managed effectively. External expertise may be required in this area. Keep the area surrounding the facility tidy and free from rubbish that may encourage pests.

The risk of physical contamination in processing areas can be high if not managed correctly. Two important areas should receive special attention and a written control policy is recommended.These areas cover glass control and knife blade control and the policy should contain these elements as appropriate.

- **Glass control**
  - Glass should not be permitted in the production area in any form. This includes windows overlooking production areas, machinery with glass parts, mirrors and ancillary equipment that may be used during production, including those necessary for the quality assurance function and the maintenance function.

  - Any raw materials that are delivered in glass containers should be decanted from the glass containers through a sieve into a plastic container prior to being taken into the production area. Consider arrangements with suppliers to provide raw materials in non-glass containers.

  - Glass containers, which are damaged on delivery or during decanting, must be discarded along with their contents.

  - The sieve should be of an appropriate mesh size to protect the raw material and should be inspected for damage prior to use. Damaged sieves should be replaced immediately.

- If glass breakage occurs in a production area for whatever reason production must be stopped in the affected area. All potentially contaminated raw materials, work in the progress, packaging and finished product should be identified systematically and removed for disposal. All pieces of broken glass should be collected and, where possible, pieced together to ensure the total item broken is found. Broken glass should be discarded and the affected area and equipment deep cleaned to remove all traces of glass. It is advisable that the cleaning is checked and signed off as satisfactory by a senior manager before production restarts. The incident should be recorded in the glass breakage log and signed off by a senior manager.

- **Blade control**
  - Knifes should only be issued to staff by an appropriate manager. The knife should be numbered and its date and time of issue recorded in a knife log book. After use, all knives should be returned to the appropriate manager and the return date and time recorded in the knife log. The knives should be inspected for damage by the manager and their details recorded in the knife log. Lost knives or damaged knives should be accounted for. Knives should be locked away when not in use.

  - In the event of a knife breaking during use production must be stopped. All potentially contaminated raw materials, work in progress and finished product should be isolated. The broken blade pieces must be recovered and pieced together to ensure that all have been accounted for. Material may have to be discarded as appropriate. The incident should be recorded in the knife log and be signed off by a senior manager.

  - Automatic cutting lines should receive careful attention. All blades on the machines should be checked for damage and wear at the start and end of the shift. The information should be recorded in a blade log dedicated to a particular machine. Any damaged or worn blades should be reported immediately to an appropriate manager who should arrange for blade replacement. This should be recorded in the maintenance records and the blade log. If applicable, spindles and blade wheels should be stored in a lockable cabinet when not in use. In the event of a blade breakage, the procedure outlined for knife blade breakage should be followed and the incident recorded and signed off in the appropriate blade log.

• Storage Facility Hygiene

Fresh produce that is stored under hygienic conditions at an appropriate temperature and humidity, is more likely to maintain its quality and hence its safety. Storage at refrigerated temperatures is recommended unless, with specific varieties, refrigeration would lead to a reduction in quality e.g. bananas.

Storage facilities can be stand-alone units or part of a processing or retail enterprise. Irrespective of the size or location the same standards apply. The fabrication of the facility should be of the same standard applied to processing and retail facilities and described in the sections on **Toilet Facilities and the Handwashing Stations** and **Processing Facility Hygiene.** Personal hygiene of workers should also be of the same standard described in section **Workers Health and Hygiene**.

Some types of fresh produce require refrigerated storage. As a general guideline, where appropriate, operating temperatures for refrigerated storage should be between 1°C and 3°C. This will not only increase the shelf life of these commodities, it will also prevent the growth of pathogenic micro-organisms if they remain on the produce. The temperature of chilled storage areas must be monitored carefully to ensure that the optimum temperature is maintained. This can be done manually on a daily basis or by using an automated temperature monitoring system. With both systems it is essential that there is a written procedure outlining the actions that need to be taken in the event of a breakdown. The actions taken should always seek to guard public health as a primary consideration.

• Transport Hygiene

Transport is a step in the fresh produce supply chain that can easily be overlooked. Poor hygienic practice at this step can contaminate a previously uncontaminated crop. Vehicles used previously to transport chemicals or manure should not be used to transport fresh produce.

Produce can easily be contaminated during transport on or off the farm. This area is often overlooked and needs to be given careful consideration. Micro-organisms and chemicals from vehicles that are not adequately cleaned and managed, can come into contact with the produce and this must be avoided. Growers, packers, shippers, exporters, retailers and wholesalers must observe good hygienic practices and these should also include the following.

- Vehicles used for transportation of produce must be inspected for odours, dirt and debris before loading. This should include the inspection of any containers that may be used during transport. Remove all foreign matter from vehicles and containers and clean appropriately.

- Produce loads being transported must always be covered with a clean cover to prevent contamination during the journey mud thrown from wheels, bird droppings etc. can all contaminate uncovered produce during transport.

- Consider the previous use of the vehicle. Vehicles used previously to transport chemicals or manure should not be used. If previous loads, prior to cleaning and sanitation, were chemicals (pesticides, fertilisers etc.), manure or animals and animal products then the risk of contamination may be high. Consider using alternative transport or, where this is not possible, clean and disinfect the vehicle appropriately.

- Where appropriate, when produce is being transported over long distance (usually off the farm), operators should work with haulage contractors to ensure that chill temperatures are maintained from the loading bay to the receiving bay.

- Produce should be loaded onto vehicles in a way that minimises damage because damaged produce is more likely to become contaminated. If chilled transport is necessary then produce must be loaded to ensure the correct airflow around the load. Training may be necessary to ensure that workers are aware of good practice in this area.

- Cleaning and sanitising vehicles can be difficult and may require expert advice.

1.4 Safe Use of Pesticides

• Hazard Identification

Pesticides are by their nature toxic substances, which interfere in the normal development of selected life forms. Most pesticides are highly selective, especially those developed over the last twenty years and only have an effect on those pests or plants to which they are applied. The introduction of a number of EU directives and their adoption under Irish legislation, has greatly improved the safety and conditions of use of pesticides in recent years. The recommendations and directions for use of a pesticide, as outlined on the label, have been developed following detailed research and evaluation. The label on the container provides precise directions as to the method of use and the precautions to be taken when applying a pesticide. It is a legal requirement that the pesticide is handled, applied and stored in accordance with the label instructions. Failure to comply with the instructions may lead to risks to the operator, bystanders, consumers or damage to crops or the environment.

The primary objective of legislation relating to the use of pesticides is to ensure that they are safe for humans, animals and the environment. In this regard all of the recommendations and statements listed on the product label are scientifically researched, to establish precise usage instructions and are legally binding on the user.

By following these instructions the grower should prevent any harmful effects arising to users, bystanders, animals, birds, aquatic organisms, other non-target organisms, soil, air, water and ultimately and most critically to consumers of food products which may contain trace residues of pesticides. Significant residues in food produce will not arise if the pesticide is applied according to the label instructions.

• Regulatory Arrangements

Pesticides include both plant protection products and biocides. Irish legislation concerning the regulation of plant protection products, in common with all EU member states, is based on a number of EU directives but primarily on Council Directive No 91/414/EEC. This directive was transposed into Irish legislation by means of Statutory Instrument (SI) No 139 of 1994, which regulates the authorisation, placing on the market, use and control of plant protection products.

Plant protection products are chemicals or biological products used to control harmful or undesired organisms and plants, or to regulate the growth of plants as crop protection agents. These are classified into a number of groups:

1 Insecticides
2 Herbicides
3 Fungicides
4 Plant Growth Regulators
5 Rodenticides
6 Molluscicides.

Similar regulatory arrangements concerning the use of biocides in Ireland has commenced with the implementation of EU Directive 98/8/EC on 13 May 2000.

Biocides are chemicals or biological products used to control harmful or undesired organisms when applied to non-plant products such as surfaces, utensils, pipework, containers, etc.. They are classified into four main groups:

Group I:	Disinfectants and general purpose biocidal products
Group II:	Preservatives
Group III:	Includes certain uses of rodenticides, avicides, molluscocides, piscicides, etc.
Group IV:	Other Biocides

Each group is subdivided into a number of product types. Two of the product types listed in Directive 98/8/EC are of particular relevance to food safety:

Type 4: Food and Feed Area Disinfectants - products used for the disinfection of equipment, containers, consumption utensils, surfaces or pipework, associated with the production, transport, storage or consumption of food, feed or drink (including drinking water) for humans and animals.

Type 20: Preservatives for Food or Feedstocks - products used for the preservation of food or feedstocks by the control of harmful organisms.

• Hazard Assessment and Risk Management

The correct use of pesticides on fresh produce is a critical step in preventing the risk of a contamination incident. Growers must be trained in the correct use of pesticides and are legally bound to use them in compliance with the label recommendations. The crops to which particular plant protection products may be applied change from time to time. Growers should not assume that a product approved for use on a crop in previous years is still allowed in subsequent years. Growers should seek regular advice from the Pesticide Control Service of the Department of Agriculture, Food and Rural Development.

A programme for the evaluation of pesticides registered within the EU is ongoing and it is proposed that all pesticides currently registered for use in the EU, but which have not yet undergone a full evaluation, will be subject to a preliminary evaluation by July 25th 2003. The EU Commission has specified that any active substance failing to meet the standards set will be withdrawn from the market after that date.

The authorisation procedure is designed to:

- Protect workers/bystanders from exposure
- Protect consumers from exposure to harmful residues
- Protect the environment from the harmful effects and accumulation of persistent pesticides
- Establish minimum efficacy standards.

The following properties of an active substance of a pesticide are evaluated prior to registration:

- Physical and Chemical
- Toxicological
- Residue potential
- Environmental
- Efficacy.

New active substances and products are subjected to a full and rigorous evaluation in relation to the above properties before they are placed on the Irish/EU market.

• Pesticide Residues in Food

- Maximum residue level (MRL)

MRL's are the regulatory mechanism used for controlling the levels of pesticide residues in food.

MRL's are based on the results of detailed supervised residue trials and feeding studies, which are used to determine the level of residues occurring at harvest, collection or slaughter etc. MRL's have been established for most fruit and vegetables, cereals and food of animal origin. There is an ongoing EU programme to set MRL's for all food produce/pesticide combinations. The most recent list of residue levels is outlined in the European Communities (Pesticide Residues) (Products of Plant Origin, including Fruit and Vegetables) Regulations, 1999. A copy of these regulations is detailed in Statutory Instrument No. 179 of 1999, which is available from the Government Publications Sale Office, Sun Alliance House, Dublin 2.

In setting MRL's for particular crop/pesticide combinations, care is taken to ensure that following use in accordance with Good Agricultural Practice (GAP), the resultant residues are such that the Acceptable Daily Intake (ADI), for the pesticide concerned will not be exceeded. The estimations made take account of all sources of exposure (food and drinking water), the consumption pattern of infants, children and adults and both average and extreme consumption patterns. The in-built safety factors typically require a lifetime of exposure at concentrations significantly greater than the ADI before consumers can be considered to be at risk.

In the case of a limited number of highly toxic pesticides, for which the ADI is necessarily based on acute toxicity rather than chronic toxicity, a single exposure through consumption of food containing high residue levels can result in acute poisoning. In assessing the effects of acute exposure, the level of exposure is considered in relation to the Acute Reference Dose (ARfD). ARfD values are a measure of the maximum level of intake at one meal, or consumption over a day. This is the maximum intake level, which is judged to result in no adverse toxicological effect following such exposure. The ARfD value includes a safety factor to ensure that the elderly, infants and children and those under stress due to illness, are protected.

Residues are controlled by limiting the maximum individual dose, maximum total dose of a pesticide applied to a crop/surface area and by specifying a Pre-Harvest Interval (PHI) through a latest time of application.

- **Monitoring of residues**
  There are approximately 800 active substances registered for use in plant protection products around the world, of which some 400 are in common use.

  In 1999 MRL's had been established in Ireland for 130 pesticides in fruit and vegetables, 78 in cereals and 61 in food of animal origin. There is an ongoing programme for the establishment of MRL's for other pesticide/crop combinations.

  Fresh produce samples are taken at wholesale and retail level and analysed to establish the identity and level of any pesticide residue present.

• Label Recommendations

Label recommendations must be approved by the Pesticide Control Service of the Department of Agriculture, Food and Rural Development and are designed to ensure that risks are highlighted and safe handling, storage and use is promoted through the inclusion of warning symbols and risk and safety phrases on the label. In order to ensure that pesticides are used safely, it is essential that all the directions for use as detailed on the label, are followed precisely. These will include some of the following:

- **Symbols**
  Most labels contain a warning symbol such as: 'The St.Andrews Cross' (irritant); 'Skull & Cross-bones' (toxic) etc.

- **Risk (R) phases**
  One or more risk phrases are normally included on the label such as: 'may cause sensitisation by skin contact'; 'toxic to aquatic organisms' etc.

- **Safety advice**
  Safety warnings include phrases such as 'when using, do not eat or drink'; 'do not breathe dust etc. Recommendations regarding the use of the pesticide are legally binding and will include some of the following:

- **Maximum individual dose**
  Maximum individual dose is established as the minimum dose necessary to control the target pest(s), without damaging non-target organisms and the environment. The maximum dose is also set at a level which will not breach the MRL or cause phytotoxicity or other damage to the crop.

- **Maximum total dose**
  Maximum total dose is established to prevent excess residue of the pesticide in the crop at harvest. It also reduces the amount of pesticide, released into the environment, thereby preventing the build-up of residues in soil, air and water.

- **Maximum number of applications**
  Limiting the maximum number of applications permitted is intended to prevent the possible development of resistance to the pesticide by encouraging other methods of control or the use of products with a different mode of action.

- **Time of application**
  Recommendations regarding application timing are established to ensure the pesticide is applied at the most appropriate growth stage of the crop, or the most effective timing for the control of the target organism.

- **Pre-harvest interval (PHI)**
  PHI is set to ensure the level of any potential residue in the produce is below the Maximum Residue Level at harvest or slaughter. This period is established following a series of trials carried out in different geographic locations over at least two years. Observance of the Pre-Harvest Interval period is critical in preventing the breaching of MRL's.

- **Spray interval**
  Spray intervals are established to give effective pest control, while minimising the possible development of resistance.

- **Crop/uses**
  Only crops/uses specified on the label are permitted for a particular pesticide. Other crops may either not have been tested, or, were tested and approval was not granted due to the residues present in the crop being in excess of the Maximum Residue Level permitted, or, due to inadequate efficacy.

- **Water volumes**
  Crops should be treated at the water volumes recommended on the label. These volumes have been tested to ensure optimum efficacy of the product.

- **Personal protective equipment**
  Recommendations to wear personal protective clothing such as gloves, eye and face protection etc. are included on the label as a result of dedicated toxicology trials and must be adhered to.

- **Methods of application**
  Only those methods of application specified on the label should be used.

- **Tank-mixing**
  Pesticides should only be tank-mixed with other products listed on the label as being compatible, as these are the only products which have been tested and approved for tank-mixing.

• Advice/Training in Relation to the Safe Use of Pesticides

Teagasc offer training programmes, through their local offices, in relation to the operation of a best Code of Practice for Pesticide Use. These programmes are also incorporated as modules in courses such as the Certificate in Farming.

A voluntary Code of Good Practice is detailed in the booklet 'Pesticides – The Handling, Application and Storage of Pesticides on Farms', which is available through local Teagasc offices.

Modules include aspects such as:

- Identity of the pest/disease/weed and the severity of the infection/infestation
- Selection of the most appropriate pesticide
- Operation and maintenance of spraying equipment
- Observance of label recommendations relating to operator exposure, environmental considerations, (wind speed, buffer zones, etc.) and the prevention of residues at harvest (pre-harvest interval, accuracy of application, etc.)
- Record keeping.

Overall pesticide legislation is intended to minimise the total amount of pesticide used, while maintaining acceptable efficacy. However, the grower can also reduce the total amount of pesticide used by:

- Preventing the initial severity or build-up of pest infestation by use of resistant cultivars, good crop rotation, good hygiene practices etc.
- Monitoring crops to ensure the best product is used at the most appropriate timing
- Integrating management techniques such as mechanical, biological and chemical means.

Pesticides should only be used where necessary, and at all times in accordance with label recommendations to minimise their impact on man, animals and the environment. Prevention of excess residues in food produce at harvest is of paramount importance.

Advice on the most appropriate use of pesticides is available from Teagasc personnel and other crop protection consultants.

• Integrated Crop Management (ICM)

(adapted from Bord Glas Quality Manual)[10]

It is recommended that producers adopt integrated crop management practices in the production of crops. This may reduce any potential risks of food safety hazards associated with chemical usage on crops. Growers should adapt their growing practices in line with the Horticultural Industry Forum Codes of Practice based on ICM procedures. (see Glossary of Terms).

The aim of ICM is to utilise long-term sustainable cultural practices that will economically produce high quality, fresh produce with a minimal impact on the environment by minimising the use of pesticides and fertilisers. This in turn will have the added benefit of reducing the risk of chemical contamination of fresh produce.

ICM is part of an approach to whole farm management in which the producer seeks to conserve and enhance the environment while producing safe, wholesome food, economically. It is based on understanding pest and disease biology and their ecological interactions within the nutrient cycles of crops. It also promotes optimising the use of natural resources such as farm manure.

ICM systems comprise many husbandry disciplines including integrated pest management (IPM). It gives priority to natural, biological, cultural and plant breeding measures. Pesticides and fertilisers are only employed when without their use, significant economic losses would occur, due to a reduction in crop yield or quality.

Applications of Crop Protection Products are based on known threshold levels of economically damaging pests, diseases and weeds. Regular monitoring of the crop, by a person experienced in the identification of pests, diseases, weeds, nutrient deficiency and beneficial insects, is required before any treatments are made. Many methods of crop monitoring are being developed and where possible, should be used or adapted to specific growing situations e.g. pheromone traps, sticky traps, pest incidence forecasts, disease infectivity models etc. Once a threshold has been exceeded, then the least damaging, most specific treatment that poses the least risk to humans, animals or the environment is applied. All treatments to a crop must be justified.

During crop harvesting and marketing, records of any treatments are recorded in a pesticide application record book, showing clearly the reason for the treatment, together with the permissible pre-harvest interval. Records are also kept of the levels of any losses and the principal causes identified. This information is then used to aid decision making and control in the following season. By keeping detailed records, growers build up their own database to produce specific site thresholds, above which they have experienced losses in yield or quality.

It is recognised that chemical fertilisers have a potentially damaging effect on the environment and have the ability to cause food safety problems. Knowledge of the soil characteristics (pH) and structure, local climate, methods of cultivation and nutrient levels are all required when assessing the growth and yield potential of crops. Soil and leaf analyses are essential when deciding on fertiliser requirements. Regular soil analysis should be carried out.

ICM requires an extremely high level of technical management and crop husbandry, but has been proven to bring significant benefits in reducing pesticide use, cost and improving the environmental impact on growing vegetable crops.

Chapter 2 : Prepared Vegetable Safety: Guide to Critical Control Points

This chapter is for guidance only and is not a substitute for carrying out a full HACCP study that must always be specific to a location and a process.

2.1 Important Note

Hazard Analysis and Critical Control Points (HACCP) studies are an essential and legal part of the operation of a food business. HACCP is the means by which food safety can be managed. However, it is not a substitute for good hygienic practice. Indeed, HACCP can only work when a company has good hygienic practices in place prior to the HACCP study. Chapter 1 contains essential hygiene information and should be consulted before embarking on a HACCP programme. It is intended that this chapter be used by HACCP teams as a guide to identify critical control points and suitable control measures for the supply of prepared fresh produce to the consumer. A HACCP plan should consider all aspects of the process, from raw materials to consumer handling.

Note: An international body, Codex Alimentarius http://www.fao.org/es*/esn/codex/ is currently working on a draft code of hygienic practice for pre-cut raw vegetable products ready for human consumption.

2.2 Hazard Identification

In its harvested state, fresh produce is protected by its natural skin, shell or outer leaves. In this state its shelf life can be relatively long provided the correct conditions of temperature, humidity, gas mixture and gentle handling are maintained. When any type of produce is processed from its 'as grown' to its prepared state, significant changes take place. The outer skin or natural protective coating is removed and the inner core or body of the produce is generally cut into many smaller pieces, thus exposing a far greater surface area. Produce will deteriorate at accelerated rates because of this. Firstly, enzymes cause physical and chemical changes to the processed product (e.g. browning or oxidation on produce such as peeled potatoes, peeled apples, types of lettuce etc). These are not food safety issues. Secondly, micro-organisms can cause spoilage, reducing the shelf life of prepared produce and in certain circumstances, creating a food safety hazard.

The greatly increased surface areas of cut produce, combined with the greater availability of nutritional tissues enables any pathogenic bacteria to rapidly multiply. Because prepared produce – in the context of this document – is fresh, uncooked and not frozen, there can be no effective heat treatment applied to cause pasteurisation or sterilisation. Instead processors of fresh produce must, in the interests of food safety, apply strictly controlled processing methods, standards and practices.

The growing popularity of prepared salads with protein components may increase the likelihood of bacterial growth. This must be taken into account when determining shelf use etc.

2.3 Hazard Control

Hazard Analysis and Critical Control Points analysis (HACCP) etc. should be used as a management method to help ensure food safety. In recent years HACCP has evolved to become the most relevant food safety management system. HACCP involves a team of relevant experts forming a constructive working team and examining the various areas of potential "hazard" associated with the particular product process. These experts, who would generally come from areas such as growing, produce storage, produce processing, distribution, packaging etc., form a team to identify the hazards associated with each process and product and then put in place the critical control points around which safety controls are designed. Prepared vegetables and ready-to-eat salads are usually eaten by the consumer without any further processing or washing. Because of this it is absolutely essential that the highest standards of hygiene are enforced in conjunction with a detailed HACCP plan. These standards, because of the nature of the end product, are more onerous than would apply to a conventional pack-house type operation.

• Suggested Critical Control Points

All operations and practices carried out in the processing step should be in accordance with good hygienic practice. These are outlined in I.S. 341 : 1998 (Hygiene in Food Retailing and Wholesaling), I.S. 342 : 1997 (Guide to Good Hygienic Practice for the Food Processing Industry in accordance with Council Directive 93/43/EEC on the Hygiene of Foodstuffs), Section 1.3 of this document and in the Bord Glas Quality Manual.

• Raw Material, Transport, Storage

It is important that processors ensure they are supplied with good quality, safe fresh produce. If high levels of contamination exist on the raw material then it is unlikely that further processing will be able to reduce it to safe levels. Processors must ensure that the produce they accept into their premises has been produced in accordance with good agricultural practices such as those outlined in the body of this report (section 1) and those outlined in the Bord Glas Quality Programme Manuals. Similarly, they must ensure that produce is not further contaminated during transport to the factory and storage prior to processing. Adherence to good hygienic practices in these areas detailed in Storage Facility Hygiene and Transport Hygiene is necessary and these should be supplemented with additional measures as required by local facilities and working practices.

• Process Flow

Good processing design requires the segregation of 'Low Care' and 'High Care' production areas. This means that processed product is washed thoroughly from a 'Low Care' preparation area to a 'High Care' area. In the 'Low Care' area, product is initially prepared, washed or peeled so that it can be effectively washed through a partition from 'Low Care' to 'High Care'. In a 'High Care' area, the contamination risk by foreign bodies such as packaging, metal, poor hygiene conditions etc. is reduced to the absolute minimum through good hygiene practice. Segregation of processing personnel within both areas is critical. Good manufacturing practice dictates that packaging surrounding produce that has arrived from the field or storage area must travel in a reverse direction from the produce.

• Washing

(read in conjunction with the section on Processing Water).

Washing is a very critical part of any produce preparation process especially if a raw, processed fresh produce is sold as 'ready-to-eat'. Washing serves three purposes and the correct washing process must be accurately designed, controlled and applied to the correct type of produce. Washing should:

- remove pieces of actual dirt and debris
- reduce the microbiological and chemical load on the produce
- reduce the temperature of the finished product to help enhance shelf-life.

An optimum washing system for any prepared vegetable process generally consists of three separate washing stages and three tanks. The first of these tanks aims to eliminate general field dirt and debris. A flotation washing system, where high volumes of air are blown into the tank through spare pipes located 10-12 inches beneath the surface of the water, is the preferred solution for products that float. This creates a violent jacuzzi effect which causes produce to tumble around. Any accompanying dirt and debris should be loosened and washed off – if such dirt and debris is likely to float, a proper design will incorporate a system to remove floating debris. Dirt and debris that sinks to the bottom of the tank should be released through a periodic drainage system with ongoing water renewal by fresh make up water.

Chlorination is used extensively throughout Western Europe and North America. It is the most effective way of getting significant micro-organism reduction. The concentration of chlorine in wash tanks is critical – too low a concentration will have minimal effect on bacteria reduction, whereas too high a concentration can cause chemical contamination and is a safety hazard in itself. Free chlorine concentrations of 50-100 ppm (parts per million)

with a contact time of 1-3 minutes are used. The chlorine concentration is best controlled by automatic chlorine monitoring and dosing equipment because chlorine is consumed by organic material from the produce. In addition, chlorine can be stripped out of the wash water by evaporation if very turbulent jacuzzi type washing systems are employed. The residence time of the produce item within the chlorine wash tank is also very important, since an inadequate time in contact with chlorine will have a minimum effect on the microbial reduction. A residence time of product within the washing system can be easily measured by timing the dwell time of a dyed produce item within a tank incorporating an automatic wash through system. In general, the greater the chlorine concentration used then the shorter the dwell or residence time required within the tank but obviously a balance of tank capacity, allowable chlorine concentration and absence of chlorine tainting, which ensure microbial reduction, must be achieved. In addition, the water temperature within the chlorine wash tank must be carefully controlled. Processors must realise there are conflicting demands in this area. To be at its most effective, chlorine should be in water at elevated temperatures (at least 8°C-10°C). However, prepared produce will maintain its quality best if all field heat is reduced and produce is quickly brought to and maintained at a temperature below 5°C. Generally, in chlorine wash tanks a water temperature of 8°C-12°C is achieved with very careful control over the chlorine concentration (ideally this is done with an automatic chlorine monitoring and dosing system). The pH of the water also has considerable impact on chlorine efficiency. In this respect the best chlorine washing systems will also control the pH of the wash water – normally this can be done through automatic pH monitoring and injection of citric acid to achieve a pH of 6.6. Chlorine is more effective at this pH level.

A good three stage produce washing process should include a final tank stage using non-chlorinated rinse water which has been chilled to 1°C-2°C. This has the effect of removing traces of chlorine, giving the product a final wash but also very importantly, reducing the product temperature, so that the washed product leaves the wash tank at a temperature below 5°C, thus increasing its shelf life.

- **Drying**

On removal from the wash tank, excess water must be separated from the washed produce (depending on the produce item). This can be achieved by simple draining for the necessary time period or alternatively where leafy bulky products are involved, by spin drying or drying in fluidised drying tunnels. Care must be taken to ensure the washed material is treated appropriately, that proper stock rotation is achieved and that the air temperature within the drying area or room is maintained as low as possible (1-5°C). If produce is left

wet and micro-organisms are present, then these may increase in number making the produce unsafe (and encourage spoilage).

- **Storage Temperatures**

Bacteria will multiply slowly at temperatures below 5°C. Their rate of growth becomes even slower at temperatures approaching 0°C. Processors, however, must be careful not to freeze the produce item since items such as leafy salads, beansprouts etc. will suffer chill/freeze damage at temperatures just below 0°C. In general most produce items will achieve maximum shelf life at temperatures 1°C-3°C. However, it is recognised that this is not a comfortable working temperature for operational staff and where labour intensive operations are involved an air temperature of 7°C-8°C is preferable. In any high quality produce preparation factory it is essential to control the air temperatures of the various storage areas very carefully. Generally where produce is contained in a storage room with no ongoing processing, air temperatures of 1°C-3°C will give the best results and where processing is undertaken, the lowest air temperatures above 0°C compatible with a comfortable working environment for staff, will again achieve the best results. Following processing, when the finished product goes into storage, temperatures should be as close to the 1°C-3°C temperature target as possible (this is only a very general outline).

Very careful temperature monitoring and control is a major requirement for the quality and safety of prepared vegetables. Now processors are advised to take manual temperature checks on a daily basis in different storage rooms, areas and zones. These manual checks have the potential to quickly highlight any breakdowns in refrigerated equipment. However, they do not always recognise defrost cycles and were generally incapable of giving average temperatures within various storage areas.

There have been great advances in computerised temperature monitoring systems. These computerised temperature monitoring systems have probes linked to software whereby the temperature is measured on very precise time intervals (programmable by the user). This is then displayed on a daily basis as an average temperature, a lowest temperature and a highest temperature within each monitored zone. This system gives best results and quickly highlights any deficiencies in refrigeration capacity or cold room loading. In addition, these electronic monitoring systems can be programmed with alarms so that if a maximum (or minimum) temperature is exceeded, the system will alarm and demand attention. Such alarmed systems can easily be linked to a telephone dialling device which will request attention from service personnel or plant operators.

- **Packaging**

Packaging materials and methods used throughout the process must be suitable for their intended purpose. General hygiene used in the production of packaging is obviously important but the processor must also ensure that the packaging material is marked as food grade (knife and fork symbol) and that it is used as specified. This will ensure that chemicals in the packaging material will not migrate into the product. Processors should familiarise themselves with the Materials and Articles in Contact with Foodstuffs Regulations SI 307 of 1991 as amended.

Many different packing formats are possible, from a standard polyethylene plastic bag through to rigid plastic containers, buckets, boxes, tubs, vacuum packing etc. In all instances, the type of packaging must be adequate for its use and application. Processors must remember that product contained therein is still alive and respiring, so for some produce items with high respiration rates e.g. mushrooms, broccoli, a packaging medium with a high permeability must be used. Permeability is the rate at which various packaging materials allow carbon dioxide and oxygen to pass through their walls and the selection of packaging material with suitable permeability is critical to good processing and in some aspects, critical to food safety standards.

If Modified Atmosphere Packing (MAP) is used the processor must ensure that the packaging and gas mixtures are appropriate for the purpose. It is essential that processors wishing to extend the shelf-life of its produce in this way obtain suitable technical advice and carry out careful shelf-life testing to ensure that pathogenic micro-organisms cannot exploit the storage conditions. Certain pathogenic micro-organisms can survive and grow without oxygen and at low temperatures over extended storage periods. In addition, MAP designed to prevent produce spoilage may inadvertently remove a natural barrier to the growth of pathogenic micro-organisms, namely competitive spoilage micro-organisms. For these reasons the application of MAP should not be considered without technical support. Consult Teagasc – The National Food Centre or the University of Limerick for guidance.

• Shredding/Size Reduction

Depending on the relevant produce and its application, various shredding or size reduction machines can be used. These are, in almost all instances, constructed of good quality stainless steel (grade 316 or better) but a very well organised competent cleaning programme must be put in place to ensure that thorough cleaning is undertaken and actually achieved on each machine every day. With all such machines, there is a potential risk of metal contamination through breakage of blades, contamination with metal etc. Produce should be passed through a metal detector as a final part of the processing operation, this should detect any product that has been contaminated with metal slivers/parts.

• Order Picking and Distribution

Processing plants will either produce to order, or have a detailed plan in place to ensure first in, first out despatch of finished product. Outer packaging should have a well defined, clearly visible date coding system to allow despatch staff, drivers, goods inwards checking personnel and customers to ensure product is transported with adequate shelf-life codes. Codes are important for traceability in the event of a product recall. Finished product storage areas must have adequate temperature control and monitoring equipment to ensure correct holding temperature. Most prepared produce is best stored at temperatures of 1°C-3°C. This allows minimum microbial activity and assures best product shelf-life. Pallets must be stacked and orders picked in such a way that product is not damaged either through crushing of heavier product placed on top or through collapse of pallets in the transport stage to the final customer. In addition, the vehicle must be fitted with proper refrigeration equipment to ensure optimum temperatures are maintained. All transport used must be of clean and adequate condition to ensure no potential risks of cross contamination.

• Produce Traceability and Recall

In the event of a product recall involving food safety the owner/manager of the business should inform the Food Safety Authority of Ireland and Bord Glas immediately.

In the event of a food safety issue involving produce, it is essential the company has appropriate reaction mechanisms in place to ensure rapid response. A product recall procedure involves a strict sequence of steps which identify the product in circulation and react to remove it from circulation and thus protect the consumer from exposure to the offending product. It is the responsibility of each organisation to establish a product recall team and action procedure.

The alert for a product recall may come from:

a) The Department of Health
b) Food Safety Authority of Ireland
c) Bord Glas
d) Product supplier or distributor
e) Merchandiser
f) Customer complaint.

Generally, a product recall should include:

- An assessment of the risk of the food alert should be carried out to ensure that unnecessary recalls are not instigated
- The list of personnel constituting the Product Recall Team highlighting emergency contact details
- A report sheet detailing the following information:
  - Product affected
  - Nature of the alert (i.e. physical/chemical contamination etc)
  - Product/package description (if applicable)
  - Produce barcode (if applicable)
  - Time packaged (if applicable)
  - Grower details (if applicable)
  - Supplier details (if applicable)
  - Date of dispatch from supplier/distributor
  - Date of receipt at final use stage
  - Quantity dispatched
  - Use-by/best before date
  - Traceability codes.

- The report sheet should be sent to all organisations potentially in receipt of, or dealing with the offending produce including: growers, suppliers, distributors, agents and retailers

- Instructions for withdrawal and impoundment of the product should be given, detailing product separation details, product recall labelling details, holding temperatures etc.
- Appropriate follow-up action needs to be outlined to give documented evidence and quantification of:
  - produce in stock holding at grower/supplier/retailer
  - produce dispatched
  - impounded produce
  - produce potentially - sold
  - produce returned to supplier/distributor.

Traceability codes and identification details should identify the primary source of the recalled product. The supplier/grower in question may be required to cease supply/production of the product until certification can prove that the source of the problem has been eliminated. Explanations detailing the cause of the problem will be required in addition to defined corrective action. As part of this corrective action, a review of procedures may be required to rectify the source of the problem.

A trial run of a product recall procedure should be carried out to ascertain the efficacy of the product recall procedure and the accountability of personnel involved on the product recall team.

• Microbiological Testing

When performing microbiological tests the results are measured against microbiological criteria which may be set by industry itself, enforcement agencies and national and international committees. Microbiological criteria are essentially of three types, Guidelines, Standards and Specifications[11].

- **A microbiological guideline** is a criterion which relates to the microbiological condition of the food sample that is applied at any stage of food processing and retailing. It aids in identifying situations requiring attention for food safety or quality reasons. Guidelines arise from many sources - the food industry, enforcement agencies and national[12] and international committees. While guidelines may be written in law they are not legally enforceable. They serve to provide assistance to enforcement agencies in interpreting whether producers are complying with the general policy in relation to standards

- A **microbiological standard** is a microbiological criterion contained in a law where compliance is mandatory. The food industry must ensure full compliance with these standards which are monitored by enforcement agencies
- A **microbiological specification** is a microbiological criterion applied to raw materials, ingredients or the end-product which is used in a purchase agreement. Specifications are set by purchasers and are usually more stringent than microbiological standards in order to provide an extra margin of safety.

In applying microbiological criteria a number of limitations should be noted, not least the statistical problems associated with selecting samples for analysis. Any single sample tested for detection or enumeration may not be fully representative of the entire food item. In the absence of 100% testing but by the application of statistical techniques to sampling, the degree of assurance derived from a result will depend in part, on the number and size of samples taken.

Furthermore, no microbiological method is capable of detecting all representatives of the target micro-organism being sought, particularly because of the presence of non-culturable or sub-lethally injured cells. There are also unavoidable differences in technique from person to person and between the sources and method of composition of media ingredients. Because of these factors, confidence limits for results from enumeration techniques are relatively wide.

Despite these limitations, the use of microbiological testing plays an important part in the hazard analysis process. When used regularly, non-statistical microbiological sampling and testing schemes are cost effective, in that they provide a simple form of monitoring that can allow trends to be identified and add to the assurance that the process is under control. The constructive use of microbiology, together with other process control systems helps to ensure that fresh produce is safe and of good quality.

Chapter 3 : Retail Sale of Fresh Produce: a Guide to Critical Control Points

This chapter is for guidance only and is not a substitute for carrying out a full HACCP study that must always be specific to a location and a process.

3.1 Important Note

Hazard Analysis and Critical Control Points (HACCP) studies are an essential and legal part of the operation of a food business. HACCP is the means by which food safety can be managed. However, it is not a substitute for good hygienic practice. Indeed, HACCP can only work when a company has good hygienic practices in place prior to the HACCP study. Chapter 1 contains essential hygiene information and should be consulted before embarking on a HACCP programme. It is intended that this chapter be used by HACCP teams as a guide to identify critical control points and suitable control measures for the retail supply of fresh produce to the consumer. A HACCP plan should consider all aspects of the process from raw materials to consumer handling.

3.2 Hazard Identification

Retail sale very often represents the final step in the fresh produce chain prior to consumption. Fruit and vegetables are particularly vulnerable at this stage, to the growth of pathogenic micro-organisms which may be passed on from personnel in contact with the produce, and the adverse conditions which may present in retailing (heat/light/outdoor conditions). It is most important that good food handling practices and temperature control are adhered to at this stage in the food chain in order to continue and maintain food safety in the chain 'from farm to fork'. The following points demonstrate the main areas of potential hazard to food safety from transport to distribution depots, through to retail sale.

- Transport to the central distribution centre (CDC) or retail outlet
- Fresh produce supplier control
- Storage in the CDC or store
- Packaging within CDC (if applicable)
- Retail sale
- Fresh produce traceability and recall
- Fresh produce shelf-life
- Produce prepared in store for deli-sale

3.3 Hazard Control

Different quality and safety management systems such as the Q Mark, ISO 9002 and HACCP (Hazard Analysis and Critical Control Points analysis) etc. can be used as management methods to help ensure food safety. Over recent years HACCP has evolved to become the most relevant food safety management system. HACCP involves a team of relevant experts forming a constructive working team and examining the various areas of potential "hazard" associated with the particular product process. These experts, who would generally come from areas such as growing, produce storage, produce processing, distribution, packaging etc., form a team to identify the hazards associated with each process and product and then put in place the critical control points around which safety controls are designed.

• Suggested Control of Critical Points

All operations and practices carried out in the retail chain should be in accordance with good hygienic practice outlined in section 1.3 of this report, in I.S. 341 : 1998 (Hygiene in Food Retailing and Wholesaling) and I.S. 342 : 1997 (Guide to Good Hygienic Practice for the Food Processing Industry in accordance with Council Directive 93/43/EEC on the Hygiene of Foodstuffs). Bord Glas Quality Manuals and I.S. 341 : 1998 (N.S.A.I.)

• Transport to the Central Distribution Centre or to the Store

Transport vehicles should be fitted with proper refrigeration and temperature logging devices to ensure optimum transport temperatures are maintained. Recommended transport temperatures (with the exception of chill sensitive commodities*), are between 1°C and 5°C. Calibration of thermometers and cooling equipment should be carried out at regular intervals to ensure compliance with specified holding temperatures. All produce containers should be stored off the floor of the vehicle on either pallets or shelving, to reduce the risk of physical contamination. This ensures good air movement and greater temperature control within the vehicle as well as reducing the risk of physical contamination. During the stacking of pallets, boxes should be stacked in alternate directions, to promote air movement and greater temperature control throughout the pallet.

*Chill sensitive commodities are those subject to chill injury when held at low temperatures. Chill injury in produce is seen as a greater susceptibility to disease as well as skin scald, failure to ripen and flesh breakdown. Chill sensitive commodities include: apricots, asparagus, avocado, banana, snap beans, cucumber, citrus fruits, peaches, peppers, plums, sweet potatoes and tomatoes.[13]

• Fresh Produce Supplier Control

Produce purchasers should use suppliers with a proven track record in supplying a quality product that is safe to eat. These, and new suppliers should be following the best practices outlined in section 1 of this document supplemented with information from the Bord Glas quality manuals. Premises and operations of all new suppliers and existing suppliers into the CDC or store, must be audited to a defined standard to assure the safety of the produce supplied. Ideally, a limited number of suppliers should be used to facilitate traceability. Produce should be inspected at delivery for date coding (if applicable), temperature, integrity of seals, cleanliness of containers etc. In addition, visual quality should be inspected for damage or physical contamination.

• Storage at the Central Distribution Centre and Store

Produce, except chill sensitive commodities, should be stored at low temperature, generally between 1°C and 3°C. Doors of chill rooms should remain closed to maintain constant temperature. Air temperatures should be logged at regular intervals with calibrated equipment. Produce received should be placed in a designated storage area, with appropriate segregation between old and fresh stock. Pallets should be labelled with the date of receipt into the premises to aid traceability. All produce should be stored off the floor (preferably on pallets), and top crates/boxes should remain covered. Any rejected/waste produce should be removed from storage areas and disposed of as soon as possible. All glassware within the storage area should be inspected regularly for breakage. Glass monitoring should take place on a daily basis, with glass breakage records completed weekly. Hazardous substances should be separated from produce (see Glass Control).

• Packaging within CDC

Prior to packaging, all produce should be inspected visually for physical contaminants and mechanical damage. Any produce showings signs of bacterial breakdown should be discarded prior to and during packaging.

All packaging operations should be carried out in accordance with good hygienic practices outlined in the section on Hygienic Practice.

Labels bearing traceability codes and correct shelf life dates should be applied to packaged produce. Any labels directly applied to produce should be made of food grade adhesive only. Records should be maintained of all labels used on produce in the event of produce being recalled at any time.

Produce should be handled gently throughout the packaging process and placed gently into outer containers. Outer containers should also be carefully stacked during assembly to avoid product damage. These containers should be clearly labelled with product description to enable handling staff maintain storage at chill temperatures.

- **Retail Sale**

All display units should be cleaned on a daily basis and any spillages occurring throughout the day should be immediately removed and the unit sanitised. Chill facilities for display of certain commodities are recommended to limit bacterial growth. Temperatures of chill units (if applicable) should be monitored twice daily with calibrated equipment, to ensure storage at the correct chill temperature. Appropriate action should be taken if temperatures are out of specification.

Produce should be handled carefully when being mounted on displays to avoid bruising and product damage. Produce should not be over-stacked in display units to avoid overheating (due to lack of air circulation), and produce bruising. Most produce, particularly soft produce, should be displayed in original containers to protect from damage. Packaged prepared vegetables should be handled with extreme care and not over-packed which could risk puncturing package seal. These packages should be stored in dark conditions prior to sale to extend shelf-life. Extreme care should be taken to ensure that these packages are not subjected to temperature abuse (>5^{o}C) during storage, which could lead to growth of food poisoning bacteria.

Produce on display should be visually inspected on a regular basis throughout the day for damage, breakdown, physical contaminants and spillages. Any poor quality produce should be immediately removed from sale and returned to the waste produce area. The ability of foodborne pathogenic bacteria to grow on cut surfaces is of utmost concern. Any produce cut for display should be covered and discarded after a defined display period.

Date code checks should be conducted morning and evening with removal of any out of date produce. Stock should be continually rotated i.e. older stock displayed towards the front. All produce should be stored in a chill area at night (if possible). Any produce remaining on shop display should be covered. All produce display cases should be cleaned after use.

Fresh produce purchased by consumers should be packaged separately from all other foods and non-food items.

• Produce Traceability and Recall

In the event of a food safety issue involving produce, it is essential that the company has appropriate reaction mechanisms in place to ensure rapid response. A product recall procedure involves a strict sequence of steps which identify the product in circulation and react to remove it from circulation and thus protect the consumer from exposure to the offending product. It is the responsibility of each organisation to establish a product recall team and action procedure.

The alert for a product recall may come from:-

a) The Department of Health

b) Food Safety Authority of Ireland

c) Bord Glas

d) Product supplier or distributor

e) Merchandiser

f) Customer complaint.

Generally, a product recall should include:

- An assessment of the risk of the food alert should be carried out to ensure that unnecessary recalls are not instigated.
- The list of personnel constituting the Product Recall Team highlighting emergency contact details.
- A report sheet detailing the following information :
  - Product affected
  - Nature of the alert (i.e. physical/chemical contamination etc.)
  - Product/package description (if applicable)
  - Produce barcode (if applicable)
  - Time packaged (if applicable)
  - Grower details (if applicable)
  - Supplier details (if applicable)
  - Date of dispatch from supplier/distributor
  - Date of receipt at final use stage

  - Quantity dispatched
  - Use-by/best before date
  - Traceability codes.
- The report sheet should be sent to all organisations potentially in receipt of, or dealing with the offending produce including: growers, suppliers, distributors, agents and retailers
- Instructions for withdrawal and impoundment of the product should be given, outlining product separation details, product recall labelling details, holding temperatures etc.
- Appropriate follow-up action needs to be outlined to give documented evidence and quantification of:
  - Produce in stock holding at grower/supplier/retailer
  - Produce dispatched
  - Impounded produce
  - Produce that may have been sold
  - Produce returned to supplier/distributor.

Traceability codes and identification details should identify the primary source of the recalled product. The supplier/grower in question may be required to cease supply/production of the product until certification can prove that the source of the problem has been eliminated. Explanations detailing the cause of the problem will be required in addition to defined corrective action. As part of this corrective action, a review of procedures may be required to rectify the source of the problem.

A trial run of a product recall procedure should be carried out to ascertain the efficacy of the product recall procedure and the accountability of personnel involved on the product recall team.

• Fresh Produce Shelf-Life

The shelf-life of fresh produce may be defined by the supplier, CDC personnel or retailer. Shelf-life predictions for retail sale should take into account shop-floor retail conditions and should be based on real time experiments. Fresh produce should be fit for human consumption for up to several days after purchase. The chill distribution chain should be maintained.

• Produce Prepared in Store for Deli Sale

Fresh produce should be prepared with utensils confined to use with fresh produce only. Containers, chopping boards, knives etc., should be cleaned and sterilised daily. Water used for produce preparation/cleaning should be clean and potable as described in Processing Water. If chlorinated wash water is to be used, chlorine levels should not exceed the recommended levels.

Conditions of storage of prepared produce should be carefully defined and in line with best practice. Use-by dates should not be longer than 1 day from preparation. Date of preparation should be noted on holding containers. Produce should ideally be covered with food grade cling film to prevent physical contamination when not on display.

Temperature control of prepared produce is of utmost importance given that the prepared produce deteriorates far more rapidly as a result of the larger exposed surface area. Prepared produce should be stored between 1°C and 3°C. Regular checks should be made on the temperature of prepared produce using a calibrated, clean temperature probe.

• Requirements for Salad Display Units

Structural

- The unit should be 1.1m in height.
- A sneeze screen/canopy must be provided in order to protect food from contamination. The distance between the unit and the base of the screen should be 225mm.
- The unit should not be more than two containers deep.
- The unit should be constructed of suitable materials and have no ridges or lips where dirt may accumulate.
- The unit should be capable of maintaining pre-chilled food at 3°C.
- All food must be stored/displayed below the level of the refrigerant coil.
- The unit should be moveable or stand 225mm clear of the ground to facilitate cleaning.
- A temperature indicating devise in centigrade degrees, preferably LED, should be provided. It should give a reading of the warmest part of the unit and be visible to the public.
- The unit should have an automatic defrost mechanism.

- Utensils at least twelve inches long should be used. These should be of suitable material, e.g. stainless steel, plastic, etc.
- Salad containers should be of a suitable material, e.g. stainless steel, plastic, etc.
- A dispenser should be provided for self-service containers. It should dispense these containers in such a way that the interiors are not exposed to contamination.

Operational

- Independent thermometers should be used by staff
- Salads should be made up and used daily. All unused salads should be discarded at the end of the day
- There must be appropriate supervision of the unit by a member of staff.

Chapter 4 : Microbiological Safety of Sprouted Seed Production

Sprouted seeds are produced in a different manner to other fresh produce and this difference makes them more susceptible to microbial contamination. The process involves soaking viable seeds in water and then placing the seed in a warm humid environment for an average of 3 to 7 days to foster germination and sprout growth. If pathogens are present in or on the seed these conditions are ideal for their growth. Pathogens can exceed 10,000,000 per gram of sprouts during sprout production without adversely affecting the appearance of the product.

The sprouting of seeds as food for human consumption has been a common practice in a number of cultures for several centuries. Many of these societies however, such as the Chinese, have traditionally consumed these products cooked and were therefore able to minimise the risk of food poisoning. In recent years the shift in consumer life style towards healthy eating has resulted in the growing popularity of the consumption of raw sprouts, such as alfalfa and bean sprouts.

4.1 Hazard Identification

While an outbreak associated with the consumption of seed sprouts, such as radish and alfalfa sprouts, has never been reported in Ireland, the past decade has seen an increasing number of outbreaks in other countries. Outbreaks have been reported in the US, Canada, UK, Sweden, Finland and Denmark. In 1996 the largest reported outbreak of *E. coli* O157 occurred in Japan. The investigation revealed that of the 10,000 people who were ill, approximately 6,000 cases were linked to the consumption of radish sprouts. There is no doubt that in the climate of healthy eating, sprouted seeds consumption has been on the increase in dishes such as salads and sandwiches. However, compared with other fresh produce, sprouts pose a special risk because of the potential for pathogens to grow during the sprouting process.

4.2 Hazard Control

Microbial contamination of sprouted seed can occur at any point in the food chain. However, because of the special nature of sprouts, this discussion will focus on two areas of concern, i.e. (i) seed production (which is not done commercially in Ireland) and (ii) sprouted seed production. Contaminated seed is the most likely source for most reported sprout associated outbreaks. However, it should be remembered that as with other fresh ready-to-eat produce, contamination may occur at any point in the farm to fork chain.

• Seed Production

For more detailed sources of seed contamination in the agricultural environment see Chapter 1. Points relevant to seed procurement and storage are:

- The purchase of certified seed from a reputable supplier.
- The potential for seeds to become contaminated post-harvest can be reduced by developing and implementing seed cleaning, storage and handling procedures that minimise potential sources of contamination.
- Damage to seeds, either inadvertent or deliberate (i.e. for the purpose of changing the seeds' germination characteristics) could aggravate contamination by making removal of pathogens during subsequent steps more difficult.
- Once present in the seed, pathogens may survive for months.
- A number of seed treatments have been shown to be effective in reducing pathogenic micro-organisms present on seeds[14].

These treatments include:

- Chemical washes (see Processing Water)
- Heat treatment:
    - Temperatures of between 54°C to 66°C for 5 to 10 minutes have resulted in pathogen reduction, however
    - The higher the temperature the greater the seed damage that will be incurred, therefore
    - It is inadvisable to rely on heat treatment alone.
- Irradiation (permissible in the US and under review in Europe).The individual treatments are thought not to be sufficient to completely eliminate the pathogens and therefore combinations of treatment may be the most effective approach. Some of these treatments may be applied during seed production stage and others at the sprout production stage
- Seeds vary in their sensitivity to antimicrobial treatments, which determines how well they germinate and grow after treatment. Therefore trials should be undertaken to establish optimum treatment for a given seed type.

• Sprout Production

In Ireland imported seed is used in the commercial production of sprouted seeds. As seeds are thought to be the most likely source of contamination, it is important that they are always purchased from a reputable supplier who can supply certification from an accredited laboratory.

Other possible sources of contamination include untreated or improperly treated water, poor sanitation of equipment and poor personal hygiene. In terms of the microbial safety of sprouts the following should be considered during the sprouting process[15]:

- The dried seed should be sampled and tested microbiologically upon arrival (see table 4.1). Seed contamination is thought to be sporadic, at low levels or unequally distributed throughout seed lots. Therefore, a negative result does not guarantee the absence of pathogens, however a positive result allows a producer to avoid using contaminated seed lots. It should be remembered that even low levels of pathogens are a concern giving the ideal conditions during sprouting for these pathogens to multiply.
- Seeds should be stored in a clean dry environment under conditions that prevent contamination (e.g. off the floor and away from the walls to reduce rodent contamination).
- Water used for seed washing, soaking, germination, growing and final product washing, should be of potable quality.
- Seeds should receive a pre-soak cleaning to remove any foreign matter and organic matter (which would negate the effects of chlorination). Dry sieving, washing in mild detergent or rinsing in chlorinated mains water (e.g. 2-4 ppm free chorine) may be used.
- In order to decontaminate the surface of the seeds they should be soaked initially in water containing a high level of decontaminant (e.g. 100-200 ppm total chlorine). Adequate contact time should be allowed for the inactivation (i.e. a minimum of 30 minutes). This time should be controlled and recorded. Following surface decontamination the seeds should be drained and then rinsed in chlorinated mains water (e.g. 2-4 ppm free chlorine) until the water runs clear.
- Containers used for germination should be cleaned and disinfected before use.
- Water used for germination should be chlorinated (i.e. 100-200 ppm total chlorine).
- Water used for irrigation during growth of the sprout should be treated to remove micro-organisms. When using chlorinated irrigation water it is recommended that the chlorine levels are monitored and recorded at least once a day[13]. Monitoring of chlorine levels provides a rapid indication of the quality of the water.
- Post-harvest sprouts should be washed in order to remove the seed coat and reduce microbial load. Initial washing should be with water containing levels of 100-

200 ppm total chlorine and preferably chilled.The final wash should be with chilled water (3°C) containing 2-4 ppm free chlorine. The sprouts should be at a temperature of <10°C prior to packing. If not packed immediately they should be stored at 3°C.

- Packing of the finished product should be carried out in a separate area to that used for growing and washing.
- The final product should be stored at a temperature of 3°C with a product temperature of less than 3°C.
- Structural and operational hygiene should be as outlined in Hygienic Practice.
- Records should be kept to facilitate traceback.

Table 4.1 Microbiological Guidelines*

Sample	Dried beans	Final product
Test	*Salmonella* *E. coli*	*Salmonella* *L. monocytogenes* *E. coli*
Suggested freguency of test (minimum)	20 x 25 samples per consignment 5 x 20g samples per consignment	2 samples/day/production line 2 samples/day/production line 2 samples/day/production line
Suggested sample size	20 x 25g 5 x 20g	25g 25g 20g
Suggested limit	Absent in 25g <10/g	Absent in 25g Absent in 25g <103/g

*These guidelines are not intended to be used as standards but rather as a guide to the frequency and type of tests to be performed (Adapted from Campden & Chorleywood, Technical Manual No. 25[1])

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Sources
Campylobacter	This bacterium is the most common cause of diarrhoea in Ireland. The infectious dose is quite low - as few as 500 cells can cause illness.	2-5 days	Moderate to severe diarrhoea. Severe abdominal pain and sometimes bloody diarrhoea.Vomiting is rare.	1-7 days	It is found in the intestine of a large range of warm-blooded animals but is especially common in birds (both wild and domestic). Mode of transmission - food and water.
Escherichia coli	*E. coli* may be divided into the following groups based on the mechanism causing illness.				Intestinal tract of humans and warm-blooded animal.
Enteropthogenic (EPEC)		12-72 hours	Diarrhoea.	< 2 weeks	Mode of transmission - person to person spread, food and water.
Enteroinvasive (EIEC)		12-72 hours	Diarrhoea (sometimes bloody diarrhoea).	5-7 days	Mode of transmission - food and water.
Enterotoxigenix (ETEC)	Associated with travellers' diarrhoea - typically in people travelling from areas with good hygiene to areas with lower hygiene standards.	12-72 hours	Diarrhoea , fever, abdominal pain and nausea (vomiting rare).	3-5 days	Mode of transmission - food and water.

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Enterohaemorhagic (EHEC) also called *Verocytotoxigenic* (VTEC)	*E. coli* O157 was first recognised in 1982. The infectious dose for VTEC has been reported to be as low as 10 cells. *E. coli* O157 and *E. coli* O26 have been isolated in Ireland.	1-6 days	Diarrhoea and sever abdominal cramps, bloody diarrhoea, haemorrhagic colitis (HC), approx. 5% (mostly children) develop haemolytic uraemic syndrome (HUS).	4-6 days (if not HUS)	Mode of transmission - Food, person to person spread and water
Salmonella	There are over 2,000 types of *Salmonella*. *S. typhimurium* and *S. enteritidis* are the most commonly isolated in Ireland.	Usually 12-36 hours but can be 6-72 hours	Fever, abdominal pain, diarrhoea, nausea and sometimes vomiting. It can be fatal in the very young, the elderly and those with weakened immune systems due to illness.	2-5 days	Both animals and humans may shed Salmonella in their faeces while displaying no symptoms of illness. Mode of transmission - food and person to person spread.
Shigella	*Shigella* is rarely transmitted by food but outbreaks have been associated with salads.	1-7 days	Symptoms vary from mild diarrhoea to dysentery.	<2 weeks	Humans Mode of transmission - person to person spread rarely by food and water

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Clostridium perfringens	*Cl. perfringens* was originally known as the cause of gangrene. Illness results from the production of a toxin in the intestine. Relative to *Cl. botulinum*, it produces a mild form of food poisoning.	Usually 12-18 hours but can be 8-22 hours	Diarrhoea and severe abdominal pain.	24 hours	The organism is widely distributed in nature - soil, human and animal faeces. *Cl. perfringens* cells can form resistant structures called spores. The function of these spores is to assist in survival and dispersal of the organism. Mode of transmission - food
Listeria monocytogenes	*L. monocytogenes* does not cause illness in most people. Those at risk include, the very young and the very old, pregnant women and generally people with weakened immune systems. *L. monocytogenes* is noteworthy for its ability to grow at refrigeration temperatures.	3 days to 10 weeks	Flu-like symptoms, meningitis and/or septicaemia. While pregnant women may experience a mild flu-like illness infection may result in miscarriage, stillbirth or birth of a severely ill infant.	Variable	The intestinal tract of many animals and humans. Mode of transmission - food and congenital.

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Yersinia enterocolitica	*Y. enterocolitica* is able to grow at refridgeration temperature.	3-7 days	Diarrhoea, abdominal pain and fever. Intestinal pain, especially in young adults may be confused with appendicitis.	1-3 weeks	Of the food-producing animals Yersinia is primarily associated with pigs. It is also found in dogs and cats and in the environment generally. Mode of transmission - food
Vibrio species	Vibrio species are generally associated with aquatic environments.				
V.cholera	*V. cholera* is the causative agent of cholera, one of the few foodborne diseases with the potential to become pandemic (i.e. extremely large outbreaks over a wide geographical area).	2-3 days	Diarrhoea	<7 days	Water, seafood and humans. Mode of transmission - water and food.
V. parahaemolyticus	*V. parahaemolyticus* requires a minimum concentration of salt for growth, it is therefore almost exclusively associated with marine environments.	12-18 days	Diarrhoea	<7 days	*V. parahaemolyticus* is found in marine environments (sometimes fresh water) and is consequently associated with seafood. Mode of transmission – food.

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Staphylococcus aureus	In contrast to other major types of food poisoning, *Staph. aureus* is almost always transmitted to food from a human source. Illness is as a result of a toxin formed in the contaminated food.	1-6 hours	Nausea, vomiting, abdominal pain and diarrhoea.	6-24 hours	Approximately 40% of healthy people may be carriers of *Staph. aureus* (in the nose and throat). Animals can also act as a source. Therefore foods that are physically handled and do not receive a treatment that will kill the pathogen carry a risk of being contaminated. Mode of transmission - food
Bacillus cereus *- emetic* *- diarrhoeal*	Large numbers of the organism are required to cause illness. *B. cereus* produces two types of toxin. The emetic toxin is produced in the food. The less common diarrhoeal toxin is normally produced in the intestine.	1-5 hours 8-16 hours	Nausea and vomiting. Abdominal pain and diarrhoea.	6-24 hours 12-24 hours	The organism is widely distributed in nature (including soil, water, dust and vegetation). *B. cereus* cells can form resistant structures called spores which aid in its survival and dispersal. Mode of transmission - food

Table 4.1 Microbiological Guidelines*

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Clostridium botulinum	The disease, botulism, is caused by the production (in the food) of a toxin which is one of the most potent natural poisons known. *Cl.botulinum* can only grow in the absence of atmospheric oxygen. Consequently, botulism is a problem in foods which provide a suitable anaerobic environment, e.g. improperly canned foods or traditional fermented vegetables made from contaminated fresh produce.	Usually 12-36 hours, but can be from 8 hours to 14 days	Blurred and/or double vision, dryness of the mouth followed by difficulties in swallowing and finally breathing. Vomiting and mild diarrhoea may occur in the early stages.	Can be several months	The organism is widely distributed in nature (including soil, water, dust and vegetation). *Cl. botulinum* can form resistant structures called spores which aid in its survival and dispersal. Mode of transmission - food and wound contamination.

Table 2: Viruses

Baterial Pathogens	Comment	Onset of illness	Symptons	Duration of illness	Mode of transmission	Major Reservoirs/ Source
Norwalk like Virus (NLV). Formerly called small round structured virus (SRSV)	Viruses have become increasingly recognised as a cause of foodborne illness since 1969. However, their actual role in the incidence of food poisoning is poorly understood, mainly because of difficulties in detecting viruses in food with current techniques.	1-3 days	Nausea, vomiting, diarrhoea.	1-3 days	Person to person spread, food and aerosol	The original source of all foodborne virsues is the human intestine. Viruses may be found in water contaminated with sewage, or on fresh produce harvested from soils treated with sewage sludge or polluted water.
Rotavirus		1-2 days	Diarrhoea and vomiting.	4-6 days	Person-to person spread and food	
Hepatitis A		15-50 days	Fever, anorexia, nausea, abdominal dis-comfort, often followed by jaundice.	Variable	Food, water and person to person spread	

Table 3: Protozoa

Protozoa	Comment	Onset of illness	Symptons	Duration of illness	Major Reservoirs/ Source
Cryptosporidium parvum	Like viruses, protozoa are probably under-recognised as a cause of foodborne illness. There is an increased awareness of the contamination of water supplies (potable as well as non-potable). Oocysts and cysts (stages in the life-cycle of protozoa) can persist for long periods of time in water.	2-5 days	Foul smelling diarrhoea. Possibly abdominal pain, vomiting and fever. It is associated with severe and life-threatening diarrhoea in AIDS patients.	<3 weeks	Livestock, pets and humans.
Giardia lamblia		5-25 days	Diarrhoea, abdominal pain, flatulence, loss of appetite and sometimes fever.	Variable	Mammals, birds and humans.
Cyclospora		1 week	Diarrhoea and weight loss.	5 days - several months	Humans.

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