

FOOD HYGIENE



Kavita Marwaha

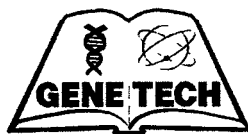
Food Hygiene

"This page is Intentionally Left Blank"

Food Hygiene

Editor

Dr. Kavita Marwaha



2007

Gene-Tech Books

New Delhi - 110 002

2007, © Publisher

Information contained in this work has been published by Gene-Tech Books and has been obtained by its author(s)/editor(s) from sources believed to be reliable and are correct to the best of their knowledge. However, the publisher and its author(s) make no representation of warranties with respect of accuracy or completeness of the contents of this book, and shall in no event be liable for any errors, omissions or damages arising out of use of this information and specifically disclaim any implied warranties or merchantability or fitness for any particular purpose.

All rights reserved. Including the right to translate or to reproduce this book or parts thereof except for brief quotations in critical reviews.

ISBN 81-89729-72-1

ISBN : 978-81-89729-72-1

Published by : GENE-TECH BOOKS
4762-63/23, Ansari Road, Darya Ganj,
NEW DELHI - 110 002
Phone: 41562849
e-mail: genetechbooks@yahoo.co.in

Printed at : Tarun Offset Printers
Delhi

PRINTED IN INDIA

Preface

Food forms one of the most essential components vital to human living, and with increasing awareness about issues of health, cleanliness and sanitation, consumers have finally woken up to the issue of food hygiene.

The main concern of a consumer lies in food safety, quality and authenticity. Food control procedures have become extremely essential in these days and age, where outbreaks of food-borne diseases are common. These procedures should not only emphasis upon maintaining hygienic food in all respects, they ought to be rapid, reliable and cost-effective.

This book describes in detail some of the food hygiene techniques employed industrially as well as in homes. It focuses on numerous kits, instruments and systems used for quality and hygiene control of food, food stuffs and food processing environment, with emphasis also being given to the validation procedures of official organisations involved in food management.

Food hygiene training is essential for anyone who handles food as part of their work and as such is a crucial element of many courses. This book has been assigned keeping in minds the needs of those who handle food in a range of occupations and it is hoped that this book is of immense use to them.

Editor

"This page is Intentionally Left Blank"

Contents

<i>Preface</i>	<i>v</i>
1. Food Hygiene	1
2. General Principles of Food Hygiene	23
3. Hygienic Food Production	50
4. Food Processing and Handling Operations	66
5. Food Storage	90
6. Food Preservation Methods	134
7. Food Poisoning and Food Borne Diseases	147
8. Developments in Food Safety and Quality Systems	179
9. Application of Microbiological Criteria for Foods	199
10. Draft Guidelines for Incorporating Microbiological Risk Assessment in the Development of Food Safety Standards	215
<i>Bibliography</i>	273
<i>Index</i>	275

"This page is Intentionally Left Blank"

Food Hygiene

People have the right to expect the food they eat to be safe and suitable for consumption. Foodborne illness and foodborne injury are at best unpleasant; at worst, they can be fatal. But there are also other consequences. Outbreaks of foodborne illness can damage trade and tourism, and lead to loss of earnings, unemployment and litigation. Food spoilage is wasteful, costly and can adversely affect trade and consumer confidence.

International food trade, and foreign travel, are increasing, bringing important social and economic benefits. But this also makes the spread of illness around the world easier. Eating habits too, have undergone major change in many countries over the last two decades and new food production, preparation and distribution techniques have developed to reflect this.

Effective hygiene control, therefore, is vital to avoid the adverse human health and economic consequences of foodborne illness, foodborne injury, and food spoilage. Everyone, including farmers and growers, manufacturers and processors, food handlers and consumers, has a responsibility to assure that food is safe and suitable for consumption.

Food (Nutrition) supplies two major components of life, energy and the chemical building blocks of life. Energy is required for the various enzymatic reactions that require an input of energy for the reactions they catalyse. For example, the movements of the muscles in our legs during a race or in our intestines as we digest our latest meal or to draw air into our lungs for breathing all require energy. Those of you who race or otherwise run for pleasure, know that it is recommended that you stock up on carbohydrates the day before a race so that you will have a ready supply of available fuel stored in your liver to supply the ATP your muscles will require.

Food also supplies the structural material required for living organisms to make new macromolecules for repair of damaged structures or for new construction, such as the manufacturing of offspring. That is, food supplies living organisms with the raw materials necessary for cell construction, as well as other essential components of life such as vitamins and minerals. A balanced and sufficient diet must contain all the calories required to maintain life and the materials for cell maintenance and construction.

Microbes play a crucial role in food resources. Microbes are responsible for the direct loss of much food through food spoilage and through the destruction of the crops and animals from whence the food comes. Conversely, microbes are responsible for manufacturing, via their biochemical activities, much of the favourite food we humans enjoy. Further, the microbes, again through their biochemical activities, preserve foods so that we can enjoy them at a later date. Finally, through their activities, microbes are vital to maintaining the fertility of the soil; so much so that we would soon starve if the soil microbes were to vanish.

To fully understand food issues, it is necessary to appreciate how much our ideas about food are the result of social training and experience. For example, everyone is aware that different social groups have different food preferences. A brief walk through downtown Pullman will take you past several ethnic eating establishments, offering a tempting variety of cuisine which most of you have probably sampled one time or another.

However, the different preferences in food across the world are enormous, including Africans that live off of fresh cattle blood and yogurt, Asians that drink urine-flavoured brews, to Eskimos who enjoy rotted fish. Many of you like buttermilk and cottage cheese, but the English consider the latter to be "spoiled milk". Conversely, many English and Scots relish a pheasant that has been hung out at room temperature for several days until it is rather "ripe". Our local meat counters offer animal intestine and testicles and some students order their pizza covered with small fish that contain their entire gut contents and others enjoy raw fish and raw oysters.

Ethyl alcohol, which is the metabolic waste, or urine equivalent, of yeast, is considered nectar-of-the-Gods by people all over the world. Other peoples relish ants, grasshoppers or bees and look forward to the harvest of these culinary delights with the same enthusiasm Americans hold for that Thanksgiving turkey. The bottom line in all cases is that whatever we label "Food", provides us with the energy and nutrients we require to maintain life.

Food and History

Food has played a critical role in history. Archeological evidence suggests that many, perhaps most, ancient civilisations disappeared as a result of losing the ability to

feed themselves. The most common reasons cited for this disaster are climate and ecological changes, combined with overpopulation. Conversely, the simultaneous growth in population and the industrial revolution were fuelled by new discoveries in agriculture that made it possible to feed many more people a good diet (well fed people do more work and work smarter).

In history you have been taught about how the "Spice Trade" was the driving force behind the intense burst of exploration that inspired Columbus, among others, to make their long and perilous voyages of discovery. Actually it was the microbes that really provided the impetus for those journeys.

In the middle ages foods like meat, milk etc. spoiled quickly, particularly on warm days. However, even spoiled meat is nutritious in spite of its rank odor and bad taste, and it beat starvation by a long stretch. Thus people, even the wealthy, frequently ate meat in various stages of active decay and pretended to actually like it. However, they found that if you added spices to this rotting meat the strong flavours the spices imparted covered up the rotten aroma and minimised gagging during dinner. Therefore, spices became the "had to have item" for every host who liked to throw parties and impress his friends.

Since spices only came from the far east by camel and small, leaky boats, those that survived the journeys were able to command top prices for these prized, gourmet, barfing-preventing items. The large profits involved stimulated an intense interest in finding quicker and safer routes to the source of these valuable spices, hence the exploration explosion of the 1400 to 1600s. One might even say that the Microbes and not Columbus discovered America.

Another role of microbes in the middle ages was that of producing miracles. It seems that the damp, dank churches of the middle ages were perfect incubators for the growth of the bacterium *Serratia marcescens* in the sacramental wafers. Under these conditions the bacterium produces a bright red pigment that resembles Blood, thus the appearance of blood-covered holy bread; clearly a miracle in the eyes of the people of that time.

Food Safety

Food safety involves more than just cleanliness; it includes all practices involved with:

- Protecting food from the risk of contamination, including harmful bacteria, poisons and foreign objects.
- Preventing any bacteria present in the food multiplying to a level that would result in food poisoning, or the early spoilage of the food.
- Destroying any harmful bacteria in the food by thorough cooking or processing.

A good knowledge of safe food handling practices is essential for all those involved in food processing, storage, distribution and sale. All food handlers **MUST** receive adequate food safety education and training that ensures:

- they are aware of the dangers of poor food handling,
- they have the knowledge to break the chain of events that results in food poisoning.

A good standard of food safety depends on foodworkers knowing :

- how the job is done,

- why it should be done, and then by doing it properly.

High Risk Foods

High Risk Foods are those perishable foods which can support the growth of harmful bacteria and are intended to be eaten without further treatment such as cooking, which would destroy such organisms. They include:

- All cooked meat and poultry.
- Cooked meat products including gravy, stock, and roll/sandwich fillings.
- Milk, cream, artificial cream, custards and dairy products.
- Cooked eggs and products made with eggs, eg. mayonnaise.
- Shellfish and other seafood.
- Cooked rice.

Kitchen Hygiene

The microbes on our food that can cause food poisoning are usually controlled by heating (cooking) and/or chilling (refrigerating) our food, but given the chance they can easily spread around the kitchen—via our hands, chopping boards, cloths, knives and other utensils. If they are allowed to cross-contaminate other foods—especially cooked and ready-to-eat foods—they can make us ill. Good kitchen hygiene and good personal hygiene are important to help control the spread of harmful germs.

Clean kitchen surfaces after preparing foods. Try to 'clean as you go'. Remember that raw meat, poultry, fish and other raw foods can easily cross-contaminate other

foods. After handling these foods always wash hands, utensils and surfaces thoroughly and before any contact with other food, especially cooked and ready-to-eat foods. After use, wash all crockery and utensils with hot water and washing up liquid. Change the water regularly then rinse in clean, hot water. Where possible leave to drain until dry.

Tea towels can be a source of cross-contamination so use them sparingly; make sure they dry out after you've used them, change them regularly and wash in a hot wash cycle. Preferably, use disposable cloths or paper towels. If you have a dishwasher use the right amounts of salt and detergent and keep the filter and all surfaces clean. The highest temperature cycle will be most effective against germs. Keep all food cupboards clean, cool, tidy and dry. When you take cans from the cupboard, before opening wipe over the tops to remove any dust. And don't forget to clean the can opener. Give your kitchen a thorough 'spring clean' periodically.

Use the right cleaning materials for the job:

- Detergents such as washing up liquids are designed to dissolve grease, oil and dirt.
- Disinfectants, such as bleach, are designed to kill germs. These are powerful agents and should not be used indiscriminately.
- Anti-bacterial cleaners are types of disinfectant and can kill germs. They often come in spray form.

Disinfectants and anti-bacterial cleaners won't work if you don't use them properly, so always follow the instructions. Always clean surfaces first with detergent to remove any grease and dirt, then apply disinfectant to kill any remaining germs. Use separate cloths or sponges for separate tasks; where practicable use disposable

cloths. If using them more than once, wash in hot water and soap then place in a suitable disinfectant, rinse thoroughly and allow to dry. Do not soak overnight as disinfectant solutions weaken and may allow bacteria to grow. Use separate buckets, cloths etc for cleaning floors.

Kitchen Rubbish Bins

Kitchen rubbish bins are an obvious breeding ground for germs, so empty them regularly—especially in the summer. Use a lidded bin and a bin liner. Tie up the rubbish bags before removing them to avoid food waste spilling onto the floor. Even with a liner, bins get dirty so clean them out with hot water and disinfectant at regular intervals.

Pests and Pets

Make sure that insects, birds and rodents are kept out of the kitchen and throw out any food they come into contact with. To control flies and wasps hang up an insecticidal strip (do not use aerosol sprays in the kitchen) and use traps for mice and rats. If the problem is serious, or if you have an infestation of cockroaches, ants or other pests, you might need to seek professional advice from your local environmental health department or a commercial pest control agency.

As much as we love our pets they do carry germs. Keep them—and their feeding bowls—away from your food and food preparation areas and wash your hands after touching them. Give pets their own feeding bowls and clean these separately from other utensils.

Personal Hygiene

Hand Washing

Some germs can stay alive on our hands for up to three

hours and in that time they can be spread to all the things we touch—including food and other people. So wash your hands regularly throughout the day and especially at these times:

Before:

- Preparing food
- Eating
- Caring for the sick; changing dressings, giving medicines
- Looking after babies or the elderly
- Starting work; especially if you are a food handler or health professional
- Putting in contact lenses

Between:

- Handling raw foods (meat, fish, poultry and eggs) and touching any other food or kitchen utensils

After:

- Handling raw foods, particularly meat, fish and poultry
- Going to the toilet
- Touching rubbish/waste bins
- Changing nappies
- Caring for the sick, especially those with gastrointestinal disorders
- Coughing or sneezing, especially if you are sick
- Handling and stroking pets or farm animals
- Gardening—even if you wear gloves
- Cleaning cat litter boxes

The number of germs on fingertips doubles after using the toilet. Yet up to half of all men and a quarter of women fail to wash their hands after they've been to the toilet! We all think we know how to wash out hands but many of us don't do it properly. Simply rinsing the tips of fingertips under cold water does not count. Here are some reminders:

- Always use warm water. It's better to wet hands before applying soap as this prevents irritation.
- Rub hands together vigorously for about 15 seconds, making sure both sides of the hands are washed thoroughly, around the thumbs, between each finger and around and under the nails.
- Then, rinse with clean water.
- Germs spread more easily if hands are wet so dry them thoroughly. Use a clean dry towel, paper towel or air dryer; it doesn't matter which.

1,000 times as many germs spread from damp hands than dry hands.

Other Personal Hygiene Tips

If you are ill, especially with any gastrointestinal problems, avoid handling foods for others. Don't sneeze or cough near foods. Cover all cuts, burns and sores and change dressings regularly—pay extra attention to any open wounds on hands and arms. Avoid working in the kitchen in soiled clothing—when cooking, use a clean apron but don't use it to wipe your hands on. If you are preparing lots of food—for a family meal perhaps—take off your watch, rings and bracelets as well as washing your hands and wrists before you start.

If you work as a food handler you should take extra precautions—and these might be required by your

employer. It's best to keep nails short and not to use artificial nails or nail varnish. Always use waterproof dressings to cover any cuts or sores. Healthcare professionals and others who look after the sick also need to take extra care. Antiseptic or alcohol-based hand washing solutions provide extra safety.

Storage Hygiene

Proper storage of food is an important part of reducing the risk of food poisoning. Some foods must be stored in the fridge and eaten within a short space of time; other foods, such as flour, pulses, canned foods and many others last much longer and can be stored at room temperature. But even dried foods have limits on their storage time. So watch out for storage instructions and make sure you always store foods:

- in the right place
- at the right temperature
- for the right time.

When shopping, buy chilled and frozen foods last. Pack them together, ideally in an insulated bag or cool box, and take them home and put them in the fridge and freezer as soon as you can. Keep raw foods (meat, fish, poultry and eggs), fruit and veg away from cooked and ready-to-eat foods. Pack foods that bruise or damage easily above other foods. Whenever carrying food outside the home (whether shopping, for barbecues or picnics) avoid putting it in warm places, eg near car heaters or in the sun. It's best to use a cool box for perishable foods.

Protect milk bottle tops from birds—if they get pecked, discard the milk. Provide a covered holder for the milkman to put milk bottles in or protective caps for

the bottle tops. Bring the milk indoors and store it in the fridge as soon as you can. If you have other perishable groceries delivered to your home, check that the carrier will store them correctly during transportation and ensure they go in the fridge as soon as they arrive. If you order hot food deliveries, check it is piping hot and eat as soon as you can.

Fridges and Freezers

Raw foods, such as meat and poultry, may contain microbes that can cause food poisoning. To prevent this, store them in the fridge. To avoid cross-contamination store these foods away from other foods, especially cooked foods and ready-to-eat foods (such as salads, fruit, cooked meats, cheeses, bread and sandwiches). Store them well covered, on the bottom shelf of the fridge so they can't drip onto other foods.

Eggs should be kept in the fridge, in their box. Keep prepared cold foods in the fridge until it's time to eat them. Dairy products belong in the fridge too. Many foods now need to go in the fridge once they've been opened—check the labels to see which ones. Never put open cans in the fridge—transfer contents into a storage container or covered bowl, and remember to use within two days. Store foods in separate covered containers. Cover dishes and other open containers with foil or film. Don't re-use foil or film to wrap other foods.

Make sure your fridge/freezer stays clean and in good working condition:

- Use a thermometer to check fridge and freezer temperatures. The coldest part of the fridge should be at no more than +5°C and the freezer at -18°C or below.

- Avoid overloading. If a fridge is over-packed with food or iced up it's harder to keep the temperature down.
- Clean all internal and external surfaces often, especially fridge shelves and door storage compartments. Mop up any spills as soon as they happen.
- Defrost your fridge/freezer regularly.

Cupboards and Storage Places

- Store root vegetables away from other fruit and veg and in a dark place.
- Keep pests out. After opening packets of dried foods (eg flour, rice and breakfast cereals) reseal them tightly or transfer contents to storage jars.
- Select storage jars and containers with tightly fitting lids—always wash and allow them to dry thoroughly after use.
- Check that safety seals are intact when first opening food packaging.
- Store cooking, eating and drinking utensils in cupboards and drawers and clean and tidy these storage spaces regularly.
- Store pet foods separately from human foods.

Storage Time

No food lasts forever however well it is stored. Most pre-packed foods carry either a 'use by' or 'best before' date. Check them carefully, and look out for advice on how long food can be kept for once packaging has been opened.

- ‘Use by dates’ –are for highly perishable foods—those that ‘go off’ quite quickly. No-one likes to waste food but it can be dangerous to eat foods past their ‘use by’ date.
- ‘Best before’ dates are for foods with a longer life. They indicate how long the food will be at its best quality.

Even if a food is within these dates don’t eat it if it looks, tastes or smells off. Always throw away any fruit or veg that has started to rot and never eat food from rusty or damaged cans, or from leaking cartons. Throw away perishable food that has been left out at room temperature for more than a couple of hours and all food scraps. Other left-overs should be stored in the fridge and eaten within two days.

Check the label on pre-packed food to see if it is suitable for home freezing. If so, freeze as soon as possible after purchase. The star marking panel on food labels will tell you how long you can store your food, depending on your type of freezer. When freezing home-cooked foods, use clean freezer bags and label them with the date and description of the food. Again, check your freezer manual or cook book to see how long you can store the foods.

Food Preparation

The germs that cause food poisoning are at greater risk of multiplying and spreading when we are handling and preparing food. At these times we need to take extra care to control food temperatures and avoid cross-contamination.

Handling Food

Wash and dry hands thoroughly before handling food.

When you can, use clean kitchen utensils not fingers for handling foods. Keep raw and cooked food apart at all times. In particular keep raw meat, fish, poultry and other raw foods away from cooked foods and ready-to-eat foods (such as salads, bread and sandwiches). Wash and dry hands, utensils—including chopping boards and knives—and surfaces thoroughly after preparing raw meat, fish, poultry and other raw foods and before contact with other food. Ideally use separate chopping boards for raw and cooked foods.

Never put cooked food onto a plate which has previously held these raw foods until it has been thoroughly washed. Do not use the same utensil to stir or serve a cooked meal that was used to prepare the raw ingredients. Root vegetables such as potatoes, leeks and carrots often have traces of soil on them which can contain harmful bacteria, so wash them thoroughly before use. Don't forget to wash other fruit and veg too, especially if they are going to be eaten raw. Avoid preparing food for yourself or others if you are ill, especially with vomiting and/or diarrhoea.

Defrosting

When cooking pre-packaged frozen foods always follow instructions on defrosting and/or cooking from frozen. If cooking from frozen allow sufficient time for food to be thoroughly cooked and check it before serving. When defrosting foods make sure they are fully defrosted before cooking. Allow food enough time to thaw. Never re-freeze food once it has started to thaw.

Thaw food by placing it on the bottom shelf of the fridge in a container to catch any juices. These juices can be contaminated so wash dishes—and hands—thoroughly after use. Only thaw food in a microwave

oven if it is to be cooked immediately. To thaw very large turkeys etc more quickly, let them defrost outside the fridge. Put them in a cool place and make sure they are completely thawed before cooking.

Cooking and Heating

Follow recipes and label instructions on cooking times and temperatures. Remember to pre-heat the oven properly. Cook all foods until they are piping hot. Double check that sausages, burgers, pork and poultry are cooked right through; they should not be 'rare' or pink in the middle and when pierced with a knife any juices that run out of the meat should be clear, not bloody. Elderly or sick people, babies, young children and pregnant women should only eat eggs cooked until both yolk and white are solid and should not eat raw or partially cooked fish and shellfish.

Lamb and beef (except when minced or rolled) can be eaten rare – but make sure the outer surface is thoroughly cooked to kill any germs on the surface of the meat. Don't cook foods too far in advance. Once cooked, keep foods covered and piping hot (above 63°C) until it's time to eat them. Keep prepared cold foods in the fridge until it's time to eat.

When using a microwave, stir foods and drinks and allow them to stand for a couple of minutes to avoid hot or cold spots. Check food is piping hot throughout before serving. Reheat foods until they are piping hot right through. Don't reheat foods more than once.

Cooling

Do not put hot food directly into the fridge or freezer, let it cool sufficiently first; but remember that cooling should be completed within one or two hours after cooking. To

speed cooling divide foods into smaller portions, place in a wide dish and stand this in a shallow tray of cold water.

Extra Care with Special Occasions

Cooking food outdoors, particularly for large groups, can increase the risk of food poisoning. It's harder to keep foods very hot or very cold and to keep everything clean. But with a little extra care barbecues can be safe as well as fun. Light the barbecue well in advance, make sure you use enough charcoal and wait until it is glowing red (with a powdery grey surface) before starting to cook.

Keep meats, salads and other perishable food in the fridge, or in a cool bag with ice packs, until just before you are ready to cook/eat them. Serve salads at the last minute. Ideally use separate cool bags for raw meats and ready-to-eat foods. Cool bags can only keep food cool for a limited period so cook sooner rather than later. Better still, if possible, fully pre-cook all poultry and sausages in the microwave or oven then take them straight to the barbecue to add the final barbecue flavour.

During cooking, turn food often. If it starts to burn on the outside raise the grill height or reduce the heat of the charcoal (dampen coals slightly or partially close air vents). As always, cook poultry, burgers, pork and sausages throughout—no pink bits in the middle. Keep raw and cooked foods apart at all times. Don't handle cooked foods with utensils that have touched raw meats and don't put cooked or ready-to-eat foods (eg salad and bread) on plates that have held raw meats. Keep serving bowls covered to protect them from dust, insects and pets.

Most people who have suffered from suspected food poisoning believe that the culprit food was eaten away

from home. You usually can't inspect the kitchens when you eat out, but there are certain warning signs of poor hygiene standards:

- dirty restaurant, dirty toilets, dirty cutlery or crockery—the kitchen is likely to be even worse
- rubbish and overflowing bins outside the restaurant—could attract vermin
- staff in dirty uniforms, dirty fingernails, long hair not tied back
- hair or insects in food
- raw food and ready to eat food displayed together
- hot food that is not cooked through properly and cold food that is served lukewarm. If you are concerned about what you are served, don't eat it

If you are concerned about the hygiene standards of a restaurant or takeaway, or you have a suspected case of food poisoning, report the case to the environmental health department of your local authority (council). This will help to ensure that other people don't suffer in the same way.

Tips for Food Sanitation

If you prepare or handle food that will be eaten, you must be sure you meet the highest standards of sanitation to make sure the food is safe to eat. While these standards are especially important if you work in a food-service operation, they are just as valid in your home kitchen, backyard barbecue, or at an office potluck.

The first part of sanitation involves your own personal hygiene:

- Don't handle food when you are sick.

- Cover cuts, burns, sores, and abrasions with a tight, dry, antiseptic bandage.
- Shower or bathe daily when you are handling food.
- Keep your clothes clean; wear an apron and change it if you wipe your hands on it or it becomes soiled.
- Keep your hair clean and tied back.
- Use soap and plenty of hot water to wash your hands frequently, especially after any act that might contaminate foods.

What sort of acts might contaminate foods? Touching your eyes, mouth, ears, nose or hair, smoking, eating or drinking, using the rest room, sneezing or coughing, using a tissue or handkerchief, handling raw food (such as unwashed fruits or vegetables or uncooked meat), taking out the trash, touching a pet or animal, or touching any dirty surfaces (such as wash cloths, money or credit cards, or soiled dishes or linen). If you wear food handler gloves, throw them away after each use, or wash your gloved hands as thoroughly as you would wash your bare hands. Gloves can spread germs just as easily as bare hands.

As you prepare food:

- Keep raw food away from ready-to-eat or cooked food.
- Keep all food away from chemicals.
- Keep cold or frozen foods out of the refrigerator or freezer for as short a time as possible.
- Wash all raw fruits and vegetables before preparation.
- Cover food during preparation.

- When plating food, avoid handling tableware that may touch people's mouths.
- Never plate food that has touched the floor, unwashed hands, or dirty equipment.
- Always use tongs or scoops when necessary. Wear latex gloves, and never touch prepared food with your hands.
- Wipe up spills promptly.
- Hold food at proper temperatures. Some safe holding temperatures for food are:
 - Stuffed meats and reheated leftovers: 165 degrees Fahrenheit (74 degrees Celsius) or above
 - Cold food: 40 degrees Fahrenheit (4 degrees Celsius) or below
 - Beef and other hot food: 140 degrees Fahrenheit (60 degrees Celsius) or above
 - Fish and poultry: 145 degrees Fahrenheit (63 degrees Celsius) or above
 - Cooked pork, pork products, hamburgers, and eggs: 155 degrees Fahrenheit (68 degrees Celsius)

Clean and sanitise equipment and utensils after each changed use. This includes knives, cutting boards, and thermometers. Storing food properly is also important:

- Do not refreeze food after it has thawed.
- Always label and date leftovers
- Store raw or thawing meats on the lowest refrigerator shelves
- Store shellfish in the original containers
- Always store food in food-grade containers and food wrap

Most harmful germs thrive in temperatures between 40 and 140 degrees Fahrenheit (4 and 60 degrees Celsius). This is known as the Temperature Danger Zone. However, that number may vary slightly as different health departments vary that amount by plus or minus 5 degrees. When you prepare food, keep it out of the Temperature Danger Zone as much as possible. Note that the Temperature Danger Zone includes room temperature. Whenever a potentially hazardous food (fish, beef, poultry, eggs, dairy products, shellfish, pork, some beans) has been in the Temperature Danger Zone for four hours or more, it should be thrown out.

Salmonella bacteria are the number one cause of foodborne infection in the United States. Typical sources of salmonella are meat, poultry, and eggs. Infection can be prevented by cooking food thoroughly and chilling leftovers rapidly. There are two special methods that can help raise the standards of sanitation in your kitchen.

The first is the two-spoon tasting method. Use a clean spoon to scoop up the item you wish to taste. Pour that food into a second clean spoon and then taste it. Never taste food over an open container. This ensures that the spoon you taste from does not go back into the food you are preparing.

The second method is also one of the most effective ways of preventing the spread of germs: hand washing. Wet your hands with hot water and wash your hands and wrists with soap for at least 20 seconds. Scrub your nails with a nail brush. Rinse your hands with hot water for 20 seconds. Follow this procedure twice after using the restroom. Dry your hands using a single-use paper towel or an air dryer. Kitchen towels can retain germs.

The methods you use for thawing food is also an integral part of safe food handling. There are three safe

ways of thawing frozen food: in a refrigerator, under running water, and in a microwave. Never thaw frozen food at room temperature. It runs the risk of contamination whenever it is left at room temperature. When thawing frozen food in the refrigerator, remove the food from the freezer. Thaw only the amount of food you need. Place the wrapped food in a shallow container on the lowest shelf of the refrigerator. Do not unwrap the food for thawing.

Make sure the refrigerator temperature is cold enough to keep the thawing food cooler than 40 degrees Fahrenheit (4 degrees Celsius). Leave the food in the refrigerator until it is totally thawed. Large amounts of food or food in boxes can take several days to fully thaw in the refrigerator. When thawing frozen foods under running water, begin by removing only the amount of food you need from the freezer.

Make sure the food is tightly wrapped or placed in a watertight container. Place the wrapped food or container under cold running water of 70 degrees Fahrenheit (21 degrees Celsius) or less. Make sure the water doesn't directly touch the food and that the food doesn't directly touch the sink. Leave the food under running water until it is completely thawed.

When thawing frozen food in a microwave oven, begin by removing only the amount of food you need from the freezer. Put the food in a microwave-safe container. Adjust the microwave setting according to the manufacturer's instructions. Start the microwave. Thaw food in a microwave oven only in emergencies. Cook food immediately after microwave thawing. Microwave cooking causes food to lose moisture and reduces its quality.

2

General Principles of Food Hygiene

The Codex Alimentarius Commission implements the Joint FAO/WHO Food Standards Programme, the purpose of which is to protect the health of consumers and to ensure fair practices in the food trade. The *Codex Alimentarius* (Latin, meaning Food Law or Code) is a collection of internationally adopted food standards presented in a uniform manner. This document follows the food chain from primary production through to final consumption, highlighting the key hygiene controls at each stage. It recommends a HACCP-based approach wherever possible to enhance food safety as described in *Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for its Application*.

The controls described in this General Principles document are internationally recognised as essential to ensure the safety and suitability of food for consumption. The General Principles are commended to Governments, industry (including individual primary producers, manufacturers, processors, food service operators and retailers) and consumers alike.

Codex General Principles

- identify the *essential* principles of food hygiene

applicable *throughout the food chain*, to achieve the goal of ensuring that food is safe and suitable for human consumption;

- recommend a HACCP-based approach as a means to enhance food safety;
- indicate *how* to implement those principles; and
- provide a *guidance* for specific codes which may be needed for—sectors of the food chain; processes; or commodities; to amplify the hygiene requirements specific to those areas.

Codex Alimentarius follows the food chain from primary production to the final consumer, setting out the necessary hygiene conditions for producing food which is safe and suitable for consumption. The document provides a base-line structure for other, more specific, codes applicable to particular sectors. Such specific codes and guidelines should be read in conjunction with this document and *Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for its Application*.

Roles of Governments, Industry, and Consumers

Governments can consider the contents of the *Codex Alimentarius* and decide how best they should encourage the implementation of these general principles to:

- protect consumers adequately from illness or injury caused by food; policies need to consider the vulnerability of the population, or of different groups within the population;
- provide assurance that food is suitable for human consumption;
- maintain confidence in internationally traded food; and

- provide health education programmes which effectively communicate the principles of food hygiene to industry and consumers.

Industry should apply the hygienic practices set out in the *Codex Alimentarius* to:

- provide food which is safe and suitable for consumption;
- ensure that consumers have clear and easily-understood information, by way of labelling and other appropriate means, to enable them to protect their food from contamination and growth/survival of foodborne pathogens by storing, handling and preparing it correctly; and
- maintain confidence in internationally traded food.

Consumers should recognise their role by following relevant instructions and applying appropriate food hygiene measures.

Use

Each section in *Codex Alimentarius* states both the objectives to be achieved and the rationale behind those objectives in terms of the safety and suitability of food.

There will inevitably be situations where some of the specific requirements contained in this document are not applicable. The fundamental question in every case is “what is necessary and appropriate on the grounds of the safety and suitability of food for consumption?” The text indicates where such questions are likely to arise by using the phrases “where necessary” and “where appropriate”.

In practice, this means that, although the requirement is generally appropriate and reasonable, there will nevertheless be some situations where it is neither

necessary nor appropriate on the grounds of food safety and suitability. In deciding whether a requirement is necessary or appropriate, an assessment of the risk should be made, preferably within the framework of the HACCP approach. This approach allows the requirements in the *Codex Alimentarius* to be flexibly and sensibly applied with a proper regard for the overall objectives of producing food which is safe and suitable for consumption. In so doing it takes into account the wide diversity of activities and varying degrees of risk involved in producing food. Additional guidance is available in specific food codes.

For the purpose of this Code, the following expressions have the meaning stated:

- *Cleaning* – the removal of soil, food residue, dirt, grease or other objectionable matter.
- *Contaminant* – any biological or chemical agent, foreign matter, or other substances not intentionally added to food which may compromise food safety or suitability.
- *Contamination* – the introduction or occurrence of a contaminant in food or food environment.
- *Disinfection* – the reduction, by means of chemical agents and/or physical methods, of the number of micro-organisms in the environment, to a level that does not compromise food safety or suitability.
- *Establishment* – any building or area in which food is handled and the surroundings under the control of the same management.
- *Food hygiene* – all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

- *Hazard*: a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.
- *HACCP*: a system which identifies, evaluates, and controls hazards which are significant for food safety.
- *Food handler*: any person who directly handles packaged or unpackaged food, food equipment and utensils, or food contact surfaces and is therefore expected to comply with food hygiene requirements
- *Food safety*: assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use.
- *Food suitability*: assurance that food is acceptable for human consumption according to its intended use.
- *Primary production*: those steps in the food chain up to and including, for example, harvesting, slaughter, milking, fishing.

Primary Food Production

Environmental Hygiene

Potential sources of contamination from the environment should be considered. In particular, primary food production should not be carried on in areas where the presence of potentially harmful substances would lead to an unacceptable level of such substances in food.

Hygienic Production of Food Sources

The potential effects of primary production activities on the safety and suitability of food should be considered at all times. In particular, this includes identifying any

specific points in such activities where a high probability of contamination may exist and taking specific measures to minimise that probability. The HACCP-based approach may assist in the taking of such measures. Producers should as far as practicable implement measures to:

- control contamination from air, soil, water, feedstuffs, fertilisers (including natural fertilisers), pesticides, veterinary drugs or any other agent used in primary production;
- control plant and animal health so that it does not pose a threat to human health through food consumption, or adversely affect the suitability of the product; and
- protect food sources from faecal and other contamination.

In particular, care should be taken to manage wastes, and store harmful substances appropriately. On-farm programmes which achieve specific food safety goals are becoming an important part of primary production and should be encouraged.

Handling, Storage and Transport

Procedures should be in place to:

- sort food and food ingredients to segregate material which is evidently unfit for human consumption;
- dispose of any rejected material in a hygienic manner; and
- Protect food and food ingredients from contamination by pests, or by chemical, physical or microbiological contaminants or other objectionable substances during handling, storage and transport.

Care should be taken to prevent, so far as reasonably practicable, deterioration and spoilage through appropriate measures which may include controlling temperature, humidity, and/or other controls.

Cleaning Maintenance and Personnel Hygiene

Appropriate facilities and procedures should be in place to ensure that:

- any necessary cleaning and maintenance is carried out effectively; and
- an appropriate degree of personal hygiene is maintained.

Food Establishments

Location

Potential sources of contamination need to be considered when deciding where to locate food establishments, as well as the effectiveness of any reasonable measures that might be taken to protect food. Establishments should not be located anywhere where, after considering such protective measures, it is clear that there will remain a threat to food safety or suitability. In particular, establishments should normally be located away from:

- environmentally polluted areas and industrial activities which pose a serious threat of contaminating food;
- areas subject to flooding unless sufficient safeguards are provided;
- areas prone to infestations of pests;
- areas where wastes, either solid or liquid, cannot be removed effectively.

Equipment

Equipment should be located so that it:

- permits adequate maintenance and cleaning;
- functions in accordance with its intended use; and
- facilitates good hygiene practices, including monitoring.

Premises and Rooms*Design and layout*

Where appropriate, the internal design and layout of food establishments should permit good food hygiene practices, including protection against cross-contamination between and during operations by foodstuffs.

Internal structures and fittings

Structures within food establishments should be soundly built of durable materials and be easy to maintain, clean and where appropriate, able to be disinfected. In particular the following specific conditions should be satisfied where necessary to protect the safety and suitability of food:

- the surfaces of walls, partitions and floors should be made of impervious materials with no toxic effect in intended use;
- walls and partitions should have a smooth surface up to a height appropriate to the operation;
- floors should be constructed to allow adequate drainage and cleaning;
- ceilings and overhead fixtures should be constructed and finished to minimise the build up

of dirt and condensation, and the shedding of particles;

- windows should be easy to clean, be constructed to minimise the build up of dirt and where necessary, be fitted with removable and cleanable insect-proof screens. Where necessary, windows should be fixed;
- doors should have smooth, non-absorbent surfaces, and be easy to clean and, where necessary, disinfect;
- working surfaces that come into direct contact with food should be in sound condition, durable and easy to clean, maintain and disinfect. They should be made of smooth, non-absorbent materials, and inert to the food, to detergents and disinfectants under normal operating conditions.

Temporary/mobile premises and vending machines

Premises and structures covered here include market stalls, mobile sales and street vending vehicles, temporary premises in which food is handled such as tents and marquees. Such premises and structures should be sited, designed and constructed to avoid, as far as reasonably practicable, contaminating food and harbouring pests. In applying these specific conditions and requirements, any food hygiene hazards associated with such facilities should be adequately controlled to ensure the safety and suitability of food.

Equipment

General

Equipment and containers coming into contact with food, should be designed and constructed to ensure that, where

necessary, they can be adequately cleaned, disinfected and maintained to avoid the contamination of food. Equipment and containers should be made of materials with no toxic effect in intended use. Where necessary, equipment should be durable and movable or capable of being disassembled to allow for maintenance, cleaning, disinfection, monitoring and, for example, to facilitate inspection for pests.

Food control and monitoring equipment

Equipment used to cook, heat treat, cool, store or freeze food should be designed to achieve the required food temperatures as rapidly as necessary in the interests of food safety and suitability, and maintain them effectively. Such equipment should also be designed to allow temperatures to be monitored and controlled. Where necessary, such equipment should have effective means of controlling and monitoring humidity, air-flow and any other characteristic likely to have a detrimental effect on the safety or suitability of food. These requirements are intended to ensure that:

- harmful or undesirable micro-organisms or their toxins are eliminated or reduced to safe levels or their survival and growth are effectively controlled;
- where appropriate, critical limits established in HACCP-based plans can be monitored; and
- temperatures and other conditions necessary to food safety and suitability can be rapidly achieved and maintained.

Containers for waste and inedible substances

Containers for waste, by-products and inedible or dangerous substances, should be specifically identifiable,

suitably constructed and, where appropriate, made of impervious material. Containers used to hold dangerous substances should be identified and, where appropriate, be lockable to prevent malicious or accidental contamination of food.

Facilities

Water supply

An adequate supply of potable water with appropriate facilities for its storage, distribution and temperature control, should be available whenever necessary to ensure the safety and suitability of food. Potable water should be as specified in the latest edition of WHO Guidelines for Drinking Water Quality, or water of a higher standard. Non-potable water, shall have a separate system. Non-potable water systems shall be identified and shall not connect with, or allow reflux into, potable water systems.

Drainage and waste disposal

Adequate drainage and waste disposal systems and facilities should be provided. They should be designed and constructed so that the risk of contaminating food or the potable water supply is avoided.

Cleaning

Adequate facilities, suitably designated, should be provided for cleaning food, utensils and equipment. Such facilities should have an adequate supply of hot and cold potable water where appropriate.

Personnel hygiene facilities and toilets

Personnel hygiene facilities should be available to ensure that an appropriate degree of personal hygiene can be

maintained and to avoid contaminating food. Where appropriate, facilities should include:

- adequate means of hygienically washing and drying hands, including wash basins and a supply of hot and cold (or suitably temperature controlled) water;
- lavatories of appropriate hygienic design; and
- adequate changing facilities for personnel.

Such facilities should be suitably located and designated.

Temperature control

Depending on the nature of the food operations undertaken, adequate facilities should be available for heating, cooling, cooking, refrigerating and freezing food, for storing refrigerated or frozen foods, monitoring food temperatures, and when necessary, controlling ambient temperatures to ensure the safety and suitability of food.

Air quality and ventilation

Adequate means of natural or mechanical ventilation should be provided, in particular to:

- minimise air-borne contamination of food, for example, from aerosols and condensation droplets;
- control ambient temperatures;
- control odours which might affect the suitability of food; and
- control humidity, where necessary, to ensure the safety and suitability of food.

Ventilation systems should be designed and constructed so that air does not flow from contaminated areas to clean areas and, where necessary, they can be adequately maintained and cleaned.

Lighting

Adequate natural or artificial lighting should be provided to enable the undertaking to operate in a hygienic manner. Where necessary, lighting should not be such that the resulting colour is misleading. The intensity should be adequate to the nature of the operation. Lighting fixtures should, where appropriate, be protected to ensure that food is not contaminated by breakages.

Storage

Where necessary, adequate facilities for the storage of food, ingredients and non-food chemicals (e.g. cleaning materials, lubricants, fuels) should be provided. Where appropriate, food storage facilities should be designed and constructed to:

- permit adequate maintenance and cleaning;
- avoid pest access and harbourage;
- enable food to be effectively protected from contamination during storage; and
- where necessary, provide an environment which minimises the deterioration of food (e.g. by temperature and humidity control).

The type of storage facilities required will depend on the nature of the food. Where necessary, separate, secure storage facilities for cleaning materials and hazardous substances should be provided.

Control of Operation

Control of Food Hazards

Food business operators should control food hazards through the use of systems such as HACCP. They should:

- identify any steps in their operations which are critical to the safety of food;
- implement effective control procedures at those steps;
- monitor control procedures to ensure their continuing effectiveness; and
- review control procedures periodically, and whenever the operations change.

These systems should be applied throughout the food chain to control food hygiene throughout the shelf-life of the product through proper product and process design. Control procedures may be simple, such as checking stock rotation calibrating equipment, or correctly loading refrigerated display units. In some cases a system based on expert advice, and involving documentation, may be appropriate. A model of such a food safety system is described in *Hazard Analysis and Critical Control (HACCP) System and Guidelines for its Application*.

Hygiene Control Systems

Time and temperature control

Inadequate food temperature control is one of the most common causes of foodborne illness or food spoilage. Such controls include time and temperature of cooking, cooling, processing and storage. Systems should be in place to ensure that temperature is controlled effectively where it is critical to the safety and suitability of food. Temperature control systems should take into account:

- the nature of the food, e.g. its water activity, pH, and likely initial level and types of micro-organisms;
- the intended shelf-life of the product;

- the method of packaging and processing; and
- how the product is intended to be used, e.g. further cooking/processing or ready-to-eat.

Such systems should also specify tolerable limits for time and temperature variations.

Temperature recording devices should be checked at regular intervals and tested for accuracy.

Specific process steps

Other steps which contribute to food hygiene may include, for example:

- chilling
- thermal processing
- irradiation
- drying
- chemical preservation
- vacuum or modified atmospheric packaging

Microbiological and other specifications

Management systems described an effective way of ensuring the safety and suitability of food. Where microbiological, chemical or physical specifications are used in any food control system, such specifications should be based on sound scientific principles and state, where appropriate, monitoring procedures, analytical methods and action limits.

Microbiological cross-contamination

Pathogens can be transferred from one food to another, either by direct contact or by food handlers, contact surfaces or the air. Raw, unprocessed food should be

effectively separated, either physically or by time, from ready-to-eat foods, with effective intermediate cleaning and where appropriate disinfection.

Access to processing areas may need to be restricted or controlled. Where risks are particularly high, access to processing areas should be only via a changing facility. Personnel may need to be required to put on clean protective clothing including footwear and wash their hands before entering. Surfaces, utensils, equipment, fixtures and fittings should be thoroughly cleaned and where necessary disinfected after raw food, particularly meat and poultry, has been handled or processed.

Physical and chemical contamination

Systems should be in place to prevent contamination of foods by foreign bodies such as glass or metal shards from machinery, dust, harmful fumes and unwanted chemicals. In manufacturing and processing, suitable detection or screening devices should be used where necessary.

Incoming Material Requirements

No raw material or ingredient should be accepted by an establishment if it is known to contain parasites, undesirable micro-organisms, pesticides, veterinary drugs or toxic, decomposed or extraneous substances which would not be reduced to an acceptable level by normal sorting and/or processing. Where appropriate, specifications for raw materials should be identified and applied.

Raw materials or ingredients should, where appropriate, be inspected and sorted before processing. Where necessary, laboratory tests should be made to

establish fitness for use. Only sound, suitable raw materials or ingredients should be used. Stocks of raw materials and ingredients should be subject to effective stock rotation.

Packaging

Packaging design and materials should provide adequate protection for products to minimise contamination, prevent damage, and accommodate proper labelling. Packaging materials or gases where used must be non-toxic and not pose a threat to the safety and suitability of food under the specified conditions of storage and use. Where appropriate, reusable packaging should be suitably durable, easy to clean and, where necessary, disinfect.

Water

In contact with food

Only potable water, should be used in food handling and processing, with the following exceptions:

- for steam production, fire control and other similar purposes not connected with food; and
- in certain food processes, e.g. chilling, and in food handling areas, provided this does not constitute a hazard to the safety and suitability of food (e.g. the use of clean sea water).

Water recirculated for reuse should be treated and maintained in such a condition that no risk to the safety and suitability of food results from its use. The treatment process should be effectively monitored. Recirculated water which has received no further treatment and water recovered from processing of food by evaporation or

drying may be used, provided its use does not constitute a risk to the safety and suitability of food.

As an ingredient

Potable water should be used wherever necessary to avoid food contamination.

Ice and steam

Ice should be made from water. Ice and steam should be produced, handled and stored to protect them from contamination. Steam used in direct contact with food or food contact surfaces should not constitute a threat to the safety and suitability of food.

Management and Supervision

The type of control and supervision needed will depend on the size of the business, the nature of its activities and the types of food involved. Managers and supervisors should have enough knowledge of food hygiene principles and practices to be able to judge potential risks, take appropriate preventive and corrective action, and ensure that effective monitoring and supervision takes place.

Documentation and Records

Where necessary, appropriate records of processing, production and distribution should be kept and retained for a period that exceeds the shelf-life of the product. Documentation can enhance the credibility and effectiveness of the food safety control system.

Recall Procedures

Managers should ensure effective procedures are in place to deal with any food safety hazard and to enable the

complete, rapid recall of any implicated lot of the finished food from the market. Where a product has been withdrawn because of an immediate health hazard, other products which are produced under similar conditions, and which may present a similar hazard to public health, should be evaluated for safety and may need to be withdrawn.

The need for public warnings should be considered. Recalled products should be held under supervision until they are destroyed, used for purposes other than human consumption, determined to be safe for human consumption, or reprocessed in a manner to ensure their safety.

Maintenance and Sanitation

Establishments and equipment should be kept in an appropriate state of repair and condition to:

- facilitate all sanitation procedures;
- function as intended, particularly at critical steps;
- prevent contamination of food, e.g. from metal shards, flaking plaster, debris and chemicals.

Cleaning should remove food residues and dirt which may be a source of contamination. The necessary cleaning methods and materials will depend on the nature of the food business. Disinfection may be necessary after cleaning. Cleaning chemicals should be handled and used carefully and in accordance with manufacturers' instructions and stored, where necessary, separated from food, in clearly identified containers to avoid the risk of contaminating food.

Cleaning procedures and methods

Cleaning can be carried out by the separate or the

combined use of physical methods, such as heat, scrubbing, turbulent flow, vacuum cleaning or other methods that avoid the use of water, and chemical methods using detergents, alkalis or acids. Cleaning procedures will involve, where appropriate:

- removing gross debris from surfaces;
- applying a detergent solution to loosen soil and bacterial film and hold them in solution or suspension;
- rinsing with water to remove loosened soil and residues of detergent;
- dry cleaning or other appropriate methods for removing and collecting residues and debris; and
- where necessary, disinfection with subsequent rinsing unless the manufacturers' instructions indicate on a scientific basis that rinsing is not required.

Cleaning Programmes

Cleaning and disinfection programmes should ensure that all parts of the establishment are appropriately clean, and should include the cleaning of cleaning equipment. Cleaning and disinfection programmes should be continually and effectively monitored for their suitability and effectiveness and where necessary, documented. Where written cleaning programmes are used, they should specify:

- areas, items of equipment and utensils to be cleaned;
- responsibility for particular tasks;
- method and frequency of cleaning; and
- monitoring arrangements.

Where appropriate, programmes should be drawn up in consultation with relevant specialist expert advisors.

Pest Control Systems

Pests pose a major threat to the safety and suitability of food. Pest infestations can occur where there are breeding sites and a supply of food. Good hygiene practices should be employed to avoid creating an environment conducive to pests. Good sanitation, inspection of incoming materials and good monitoring can minimise the likelihood of infestation and thereby limit the need for pesticides.

Preventing access

Buildings should be kept in good repair and condition to prevent pest access and to eliminate potential breeding sites. Holes, drains and other places where pests are likely to gain access should be kept sealed. Wire mesh screens, for example on open windows, doors and ventilators, will reduce the problem of pest entry. Animals should, wherever possible, be excluded from the grounds of factories and food processing plants.

Harbourage and infestation

The availability of food and water encourages pest harbourage and infestation. Potential food sources should be stored in pest-proof containers and/or stacked above the ground and away from walls. Areas both inside and outside food premises should be kept clean. Where appropriate, refuse should be stored in covered, pest-proof containers.

Monitoring and detection

Establishments and surrounding areas should be regularly examined for evidence of infestation.

Eradication

Pest infestations should be dealt with immediately and without adversely affecting food safety or suitability. Treatment with chemical, physical or biological agents should be carried out without posing a threat to the safety or suitability of food.

Waste Management

Suitable provision must be made for the removal and storage of waste. Waste must not be allowed to accumulate in food handling, food storage, and other working areas and the adjoining environment except so far as is unavoidable for the proper functioning of the business. Waste stores must be kept appropriately clean.

Monitoring effectiveness

Sanitation systems should be monitored for effectiveness, periodically verified by means such as audit pre-operational inspections or, where appropriate, microbiological sampling of environment and food contact surfaces and regularly reviewed and adapted to reflect changed circumstances.

Personal Hygiene

Health Status

People known, or suspected, to be suffering from, or to be a carrier of a disease or illness likely to be transmitted through food, should not be allowed to enter any food handling area if there is a likelihood of their contaminating food. Any person so affected should immediately report illness or symptoms of illness to the management. Medical examination of a food handler should be carried out if clinically or epidemiologically indicated.

Illness and Injuries

Conditions which should be reported to management so that any need for medical examination and/or possible exclusion from food handling can be considered, include:

- jaundice
- diarrhoea
- vomiting
- fever
- sore throat with fever
- visibly infected skin lesions (boils, cuts, etc.)
- discharges from the ear, eye or nose

Personal Cleanliness

Food handlers should maintain a high degree of personal cleanliness and, where appropriate, wear suitable protective clothing, head covering, and footwear. Cuts and wounds, where personnel are permitted to continue working, should be covered by suitable waterproof dressings. Personnel should always wash their hands when personal cleanliness may affect food safety, for example:

- at the start of food handling activities;
- immediately after using the toilet; and
- after handling raw food or any contaminated material, where this could result in contamination of other food items; they should avoid handling ready-to-eat food, where appropriate.

Personal Behaviour

People engaged in food handling activities should refrain

from behaviour which could result in contamination of food, for example:

- smoking;
- spitting;
- chewing or eating;
- sneezing or coughing over unprotected food.

Personal effects such as jewellery, watches, pins or other items should not be worn or brought into food handling areas if they pose a threat to the safety and suitability of food.

Visitors

Visitors to food manufacturing, processing or handling areas should, where appropriate, wear protective clothing and adhere to the other personal hygiene provisions in this section.

Transportation

General

Food must be adequately protected during transport. The type of conveyances or containers required depends on the nature of the food and the conditions under which it has to be transported.

Requirements

Where necessary, conveyances and bulk containers should be designed and constructed so that they:

- do not contaminate foods or packaging;
- can be effectively cleaned and, where necessary, disinfected;

- permit effective separation of different foods or foods from non-food items where necessary during transport;
- provide effective protection from contamination, including dust and fumes;
- can effectively maintain the temperature, humidity, atmosphere and other conditions necessary to protect food from harmful or undesirable microbial growth and deterioration likely to render it unsuitable for consumption; and
- allow any necessary temperature, humidity and other conditions to be checked.

Use and Maintenance

Conveyances and containers for transporting food should be kept in an appropriate state of cleanliness, repair and condition. Where the same conveyance or container is used for transporting different foods, or non-foods, effective cleaning and, where necessary, disinfection should take place between loads. Where appropriate, particularly in bulk transport, containers and conveyances should be designated and marked for food use only and be used only for that purpose.

Product Information and Consumer Awareness

Lot identification

Lot identification is essential in product recall and also helps effective stock rotation. Each container of food should be permanently marked to identify the producer and the lot. Codex General Standard for the Labelling of Prepackaged Foods applies.

Product Information

All food products should be accompanied by or bear

adequate information to enable the next person in the food chain to handle, display, store and prepare and use the product safely and correctly.

Labelling

Prepackaged foods should be labelled with clear instructions to enable the next person in the food chain to handle, display, store and use the product safely. Codex General Standard for the Labelling of Prepackaged Foods applies.

Consumer Education

Health education programmes should cover general food hygiene. Such programmes should enable consumers to understand the importance of any product information and to follow any instructions accompanying products, and make informed choices. In particular consumers should be informed of the relationship between time/temperature control and foodborne illness.

Training

Wareness and Responsibilites

Food hygiene training is fundamentally important. All personnel should be aware of their role and responsibility in protecting food from contamination or deterioration. Food handlers should have the necessary knowledge and skills to enable them to handle food hygienically. Those who handle strong cleaning chemicals or other potentially hazardous chemicals should be instructed in safe handling techniques.

Training Programmes

Factors to take into account in assessing the level of training required include:

- the nature of the food, in particular its ability to sustain growth of pathogenic or spoilage micro-organisms;
- the manner in which the food is handled and packed, including the probability of contamination;
- the extent and nature of processing or further preparation before final consumption;
- the conditions under which the food will be stored; and
- the expected length of time before consumption.

Instruction and Supervision

Periodic assessments of the effectiveness of training and instruction programmes should be made, as well as routine supervision and checks to ensure that procedures are being carried out effectively. Managers and supervisors of food processes should have the necessary knowledge of food hygiene principles and practices to be able to judge potential risks and take the necessary action to remedy deficiencies.

Refresher Training

Training programmes should be routinely reviewed and updated where necessary. Systems should be in place to ensure that food handlers remain aware of all procedures necessary to maintain the safety and suitability of food.

Hygienic Food Production

Safe food production is the number one concern for all food producers. Certified organic growers follow strict guidelines for safe and hygienic food production. As with all food producers, they must comply with local, state and federal health standards. Pasteurization, selected use of chlorine, and other food safety practices also are allowed and followed in organic production. Consumers need to follow safe food handling, no matter what type of food they purchase.

Hygiene in Food Shops

It is essential for food shops to maintain a high standard of food hygiene and sanitation to prevent the transmission and spread of infectious diseases within the premises. To qualify for the label, participating food shops will need to show commitment to the following:

- (a) Have temperature-checking regime in place for its stallholders, their assistants and cleaners
- (b) Ensure hygienic food preparation
- (c) Ensure proper storage and disposal of waste
- (d) Have a table-cleaning system

- (e) Practise good housekeeping
- (f) Have cleaning/disinfecting programme
- (g) Have a pest control programme

Temperature-Checking: Conduct daily checks on employees to ensure that those who are unwell seek proper medical attention. They should not be allowed to handle food.

Food Hygiene: All food handlers should observe good food hygiene practices to prevent food contamination and to ensure food safety. The following practices should be adhered to:

- Ensure all food sold are obtained from licensed sources.
- Keep raw food and cooked food on separate shelves in the refrigerator, with cooked food above raw food. Also, ensure that the temperature within the refrigerator is kept at the correct levels.
- Protect cooked food on display using protective showcases. Where food warmers are used to keep food warm, they should be kept above 60°C and, if food are chilled, they should be kept at below 10°C to prevent proliferation of bacteria.
- Do not keep personal belongings in food preparation areas. A separate locker area should be provided for storage of personal belongings.
- Do not use cracked or chipped crockery as germs can harbour in the cracks.
- Use separate implements and chopping boards for raw, and cooked foods to prevent cross contamination.

- When serving food/drinks, do not touch the inside of glasses or the top of plates/bowls.

Refuse Management

- Dispose of all food waste and other refuse in foot pedalled refuse bins lined with plastic bag. Clean up any refuse spillage immediately.
- Avoid touching refuse bins with hands during food preparation or while serving food.
- Remove the bags of refuse from the bins for disposal at the bin centre regularly. Ensure there is no refuse leakage and that the plastic bags are securely tied up.
- Wash and disinfect all refuse/bulk bins at the end of each business day.
- Keep all refuse bins in the stall covered when not in use.
- Check areas near the food shops for evidence of rodent and other pest infestation.

Cleanliness of Dining Areas, Tables and Seats

- Clear all soiled crockery as soon as customers leave the tables. Better still, implement a scheme to encourage all customers to clear their own soiled crockery themselves.
- Clean and disinfect the floor of the dining area, tables, chairs, etc at the end of the business day.
- Use a different coloured cloth for cleaning furniture such as tables/chairs to separate them from cloths for drying washed crockery.

Cleanliness of Facilities/Equipment

- Wash all soiled crockery/cutlery thoroughly with suitable detergent under running water. They

should be properly dried before using for the next customer.

- Clean cooking ranges and preparation tables after every preparation. Practise a 'clean-as-you-go' habit.
- Clean cooker hood and flue systems weekly.
- At the end of each business day, clean and disinfect floors, all counter tops, display showcases and other surfaces. For disinfection, prepare a simple disinfecting solution by diluting household bleach (adding 1 part of bleach to 49 parts of water or as prescribed by the manufacturers on the container).
- Keep the interior and exterior of the refrigerator/chillers/freezers clean at all times.
- Keep all food equipment (toasters, oven, electric rice cookers, coffee grinders/makers etc) clean and well-maintained at all times.
- Protect ready-to-use items such as forks, spoons, knives and chopsticks against contamination from coughs/sneezes. Wherever possible, provide these items in the pre-packed form.

Prevention of Pest Infestation

- Engage a registered pest control operator to carry out regular pest control works.
- Check the stall area daily for signs of rodent and other pest (e.g. rodents, cockroach) infestation.
- Keep all storage shelves/cabinets at least 30 cm above the floor level to facilitate cleansing and prevent harbourage of pests.
- Ensure all food are properly stored. Use storage containers with tight fitting covers to store dry food ingredients.

- Maintain good housekeeping and cleanliness of the stall at all times. Avoid storing cartons, boxes or other paraphernalia that could provide hiding places for rodents, cockroaches & other pests.

Personal Hygiene: All foodhandlers must maintain a high standard of personal hygiene to prevent food contamination and transmission of harmful pathogens. Foodhandlers should observe the following good practices at all times:

- Wear clean work clothes, uniforms and aprons at all times. Aprons should not be worn outside the food establishment or when visiting the toilet. Hair restraints should also be worn when handling food.
- Avoid touching the nose, mouth, hair or eyes when handling food.
- Do not use bare hands to handle ready-to-eat food or cooked food. Gloves, tongs or other suitable implements should be used.
- Avoid wearing jewellery or other costume accessories when preparing food.
- Wash hands with soap and water frequently especially before preparing food, after every visit to the toilet and after sneezing/coughing. Spend at least 15 - 20 seconds working up a good lather. Soaping and rinsing of hands should include areas between fingers, nails and the back of the hand up to the wrists. Dry hands with a clean disposable towel or with the hand dryer immediately after.
- Cough, sneeze, or blow your nose into a disposable tissue or napkin. Dispose of used tissue/napkin in a litter bin or flush it down the toilet bowl. Wash hands immediately after.

- Do not spit indiscriminately onto the grounds/drainage. Always use a tissue or napkin and dispose of it in a litter bin.

Hygienic Sandwich Production

Sandwiches often contain ingredients which allow bacteria to grow. It is therefore very important for them to be prepared and stored under hygienic conditions. Following the guidelines below should help to ensure the safety of the sandwiches you produce.

Ingredients

- Check packaging is intact. Do not accept ingredients if you think any damaged packaging may have affected the contents.
- Check the date codes and do not accept any products that are out of date.
- Follow the storage instructions on the packaging.
- Fresh vegetables should be rinsed with fresh chlorinated water prior to use. They should be checked to remove foreign bodies such as soil and insects.

Storage

- If raw, cooked and ready to eat foods are stored in the same refrigerator, place cooked and ready to eat foods above raw food at all times.
- Food in the fridge and freezer should be covered or stored in suitable containers with lids in order to prevent contamination of the food.
- Canned food once opened should be stored in suitable, clean and washable containers with fitted lids.

- Date code ingredients once they have been removed from their original packaging to ensure effective stock rotation.

Personal Hygiene

Good standards of personal hygiene are very important for the safe preparation of sandwiches. In particular hands should be washed after:

- handling raw food
- handling waste food and rubbish
- using the toilet
- sneezing, coughing and blowing your nose
- using cleaning materials

Preparation

- Thoroughly clean and disinfect equipment and preparation surfaces before starting work. Continue to clean and disinfect during preparation to reduce the risk of contamination.
- Sanitisers such as 'Dettol' or 'Milton fluid' are recommended as they help reduce bacteria to safe levels and are food safe.
- Use separate preparation boards and knives for raw and cooked/ready to eat foods.

Packaging, Display and Service

- Wrap sandwiches in food safe packing before display to avoid contamination from handling during service and to retain their freshness.
- It is recommended that sandwiches are stored chilled at all times. If sandwiches are not

refrigerated they should be thrown away after 4 hours or at the end of the service period whichever is the earlier.

- Wherever possible use utensils or packaging when serving the sandwiches to avoid direct contact with hands, which may be contaminated, e.g. by handling money.

Temperature Control

- All prepared fillings should be stored in a fridge until needed.
- Small quantities of fillings should be taken out as required.
- Generally foods stored in the fridge and cold display units must be kept below 8 degrees centigrade. Frozen foods should be kept below -18 degrees centigrade.
- Temperatures of fridges and freezers should be monitored and recorded on a regular basis to ensure they are operating effectively.

Labelling

Sandwiches made by a retailer or caterer for sale on the premises where they were made/packed or from a vehicle or a stall operated by the same person need to be labelled with:

- Name of the food
- A list of all additives (including those in the bread)

All prepacked sandwiches sold from premises other than where they were made/packed must be labelled with the following information:

- Name of the food

- A full list of ingredients in descending order by weight (this includes bread)
- A 'Use-by' date in the form of day/month or day/month/year
- Advice on storage
- The name and address or registered office of either the manufacturer, or in the case of a retail brand, the retailer

There are prohibitions and restrictions on the use of certain claims on labels (e.g. relating to energy values, vitamins, minerals, nutrition and cholesterol).

Hygienic Rice Cooking

Cooked rice can cause food poisoning, if left for several hours at room temperature. This is because bacteria in the rice can produce poisons at room temperature, which cannot be destroyed by further cooking or reheating. Never store cooked rice at room temperature. Either: keep it hot at 63 degrees centigrade, or above; or keep it cold, at 8 degrees centigrade or less. Follow these simple guidelines for handling rice safely.

Storage

- Store uncooked rice in pest proof containers with lids.
- Do not use old tin cans as scoops—instead, use clean plastic or metal scoops.
- Practice good stock control.

Preparation

- Wash rice thoroughly before cooking and remove any foreign bodies (e.g. stones).

- Use clean equipment.
- If possible, cook only the quantity required for each service period and throw away leftover rice.

Storage

Cool quickly: Try to cool cooked rice and place it in the refrigerator within a maximum of 1.5 hours of cooking. Cooling large quantities of cooked rice may take several hours. To reduce this time to 1.5 hours or less, divide the rice into smaller portions, or into shallow dishes.

Store in the fridge: Once cool, cover the rice and store in the fridge until needed. Cloths and towels should not be used as a cover because they can carry harmful bacteria. Instead, use clean lids, aluminium foil or clingfilm.

Reheating

Small quantities: Only remove small amounts of rice from the fridge for the cooking period—enough for about 1 hour. Keep the rest covered up in the fridge until needed.

Breaking up clumps of rice: Rice that has been kept in the fridge may stick together and form clumps. Do not use your hands to break up these clumps. Use clean utensils instead.

Reheat thoroughly: Rice must be reheated until it is piping hot throughout. A temperature of 75 degrees centigrade for at least 2 minutes must be reached.

Personal Hygiene

- Always wash hands after using the toilet and after handling raw food, rubbish and chemicals. Use hot water and soap.

- Cover cuts and abrasions with waterproof plasters, (preferably blue). Keep scaly, weeping or infected skin covered at all times.
- Do not work in the kitchen if you have sickness or diarrhoea.
- Tell your boss if you had sickness or diarrhoea while on holiday.

Use of Artificial Colours in Foods

The Colours in Foods Regulations 1995 restrict the use of artificial colours in foods. Certain foods are not permitted to contain artificial colours, while other foods are restricted to a maximum amount of colour that may be used. Basic and unprocessed foods should not be coloured. Rice is not permitted to contain artificial colour, neither are meat, or chicken. Sauces used to prepare or serve ready to eat foods may contain artificial colour. Under the Regulations sauces are permitted to contain no more than 500 milligrams per kilogram (500mg/kg) of these colours either singly or in combination.

Three common preparations purchased for use by takeaways are “Bright Red Powder”, “Deep Orange” and “Egg Yellow”. These are commonly made up of colours: Ponceau 4R (E124), Sunset Yellow FCF (E110), and Tartrazine (E102).

An excess of these colours can cause some people to suffer from headaches, migraines, breathing difficulties and allergic skin reactions. Food Labelling Regulations do not require takeaway food and restaurant meals to be marked with a list of ingredients, therefore customers must be able to rely on food businesses knowing what colours can or cannot be used. Customers should be confident that foods they buy are within the legal limit for levels of artificial colours.

Although artificial colours are allowed in sauces they are not a natural product. Sauces can be coloured using natural spices such as turmeric and paprika which do not cause health problems for customers. Businesses may need to advise their customers that the food they are selling is no longer as “bright” since they are not now using artificial colours.

Ensure all staff fully understand the importance of correctly measuring out artificial colours when making up sauces. It is important to buy colours from a reputable supplier. The tin or packet should be clearly labelled with instructions for use.

To avoid adding too much colour carefully follow the instructions ensuring that the correct quantity of colour is used for the quantity of sauce. Do not consider the amount of meat, or chicken in your calculations. The maximum levels of colours apply to sauces when ready to eat, account must be taken of the concentration affects caused by water loss during cooking.

Faultless Festive Food

At Christmas, more cases of food poisoning are reported than at any other time of year. It can not only spoil the celebrations, but can be potentially life-threatening, especially to people who may be particularly vulnerable, such as young children, pregnant women, the elderly, and anyone whose resistance may be low because they are ill.

It is important to recognise the causes of food poisoning. Some of the most common are:

- poor storage
- poor temperature control—food not being kept either hot or cold enough

- inadequate cooking
- cross contamination

Most foods can be a possible source of food poisoning bacteria of one type or another, but some are a higher risk than others, and need to be treated accordingly, such as:

- meat and meat products
- raw poultry and eggs (and foods which contain raw egg)
- fish and shellfish
- raw salads and vegetables, which will not be cooked before eating
- high protein foods such as soft cheeses and pates

At Christmas, one of the most common problems is lack of fridge and freezer space due to the large amount of food and drinks brought into the home for the holiday period. Before buying Christmas provisions, make sure that you have adequate space in your fridge and freezer to keep food at the proper temperature. Keep any raw meat or food that is defrosting at the bottom of the fridge so that it cannot drip down onto food below, and make sure that raw and cooked foods are always kept separate.

Storing foods in sealed containers in the fridge will minimise the risk of cross-contamination. If you can, invest in a fridge thermometer—the coldest part of your fridge should always be between 0°C and 5°C. Overloading the fridge will make it less efficient if the air cannot circulate freely. Keep the door closed as much as possible—leaving it open will raise the temperature inside quite rapidly, especially if the kitchen is very warm because you are cooking.

Food that will not be cooked further and is left standing around at room temperature is an ideal

environment for food poisoning bacteria to grow. Leave the preparation of food that will need to be stored in a refrigerator till last and then refrigerate as soon as possible, but do not put it into the fridge while still warm as this will raise the temperature inside. There are a number of ways to cool food rapidly:

- by placing covered food in the coolest place possible (possibly not in the kitchen)
- by putting food in a sealable container and placing it in cold water
- by using ice packs and cool bags Remember, if you are cooking a large amount of food, such as a big joint of meat, cutting it into smaller pieces will allow it to cool more quickly.

If you have food that needs to be kept hot until it is served, for example, if you need to take the turkey out of the oven before you have room to cook everything else, you must make sure that the food is held at a high enough temperature (above 63°C) to stop bacteria multiplying. If the food is kept warm, but at a lower temperature than this, bacteria will multiply happily. Also beware of serving meat cool but pouring warm gravy over it—this can have the same effect.

Make sure meat and poultry are thoroughly thawed before cooking. Turkeys in particular need plenty of time to thaw out simply because of their size. Follow the thawing instructions on frozen meat and poultry carefully and check that there are no ice crystals in the body cavity and that the legs are flexible. If at all possible, thaw in the fridge.

When cooking, make sure the centre of the meat is well cooked and the juices run clear. A meat thermometer is a worthwhile investment as ensuring that the centre of

the meat reaches at least 70°C for a sufficient time is the key to killing food poisoning bacteria. Bear in mind that a stuffed bird will take longer to cook through and ideally, stuffing should be cooked separately.

Once food is cooked, it should not be reheated more than once. When reheating, make sure that food is piping hot all the way through. Store any leftovers in clean containers in the fridge and use them within 48 hours or throw them away. Don't leave leftovers standing around at room temperature for more than an hour or two before refrigerating them.

Cross-contamination is the transfer of bacteria from a source to an already prepared food. The source could be raw foods, hands, animals, work surfaces, dirty utensils or cloths. The risk of cross-contamination may be increased at Christmas when lots of different foods may be being prepared, and more pots, pans and utensils are being used. Using basic food hygiene techniques will dramatically reduce the risk.

Prepare raw food separately from cooked, and don't use the same knife or chopping board for raw meat, cooked foods and raw vegetables or fruit without thoroughly cleaning in hot soapy water between times. Wash salads, fruit and vegetables thoroughly. Keep work surfaces, plates, utensils, etc. clean by washing in hot water and detergent, and always keep your hands clean while handling food, especially after using the toilet, or handling rubbish or pets.

Remember to wash your hands between handling raw and cooked foods, and make sure all cloths and towels used in the kitchen are clean and changed frequently. Anyone suffering from a stomach upset should be kept away from the kitchen, and any cuts or grazes covered with waterproof plasters. Keep food covered, and dispose

of waste food and other rubbish carefully in bins with lids.

Keep pets out of the kitchen, especially when food is being prepared. By being aware of potential risks, and following good hygiene practices, you can effectively minimise the risk of food poisoning.

4

Food Processing and Handling Operations

The objective of cleaning and sanitising food contact surfaces is to remove food (nutrients) which bacteria need to grow, and to kill those bacteria which are present. It is important that the clean, sanitised equipment and surfaces drain dry and are stored dry so as to prevent bacteria growth. Necessary equipment (brushes, etc.) must also be clean and stored in a clean, sanitary manner.

Cleaning/sanitising procedures must be evaluated for adequacy through evaluation and inspection procedures. Adherence to prescribed written procedures (inspection, swab testing, direct observation of personnel) should be continuously monitored, and records maintained to evaluate long-term compliance. The correct order of events for cleaning/sanitising of food product contact surfaces is:

- Rinse
- Clean
- Rinse
- Sanitise.

Cleaning Methods

Cleaning is the complete removal of food soil using appropriate detergent chemicals under recommended conditions. It is important that personnel involved have a working understanding of the nature of the different types of food soil and the chemistry of its removal. Equipment can be categorised with regard to cleaning method as follows:

- Mechanical Cleaning. Often referred to as clean- in-place (CIP). Require no disassembly or partial disassembly.
- Clean-out-of-Place (COP). Can be partially disassembled and cleaned in specialised COP pressure tanks.
- Manual Cleaning. Requires total disassembly for cleaning and inspection.

Sanitisation

It is important to differentiate and define certain terminology:

- Sterilise refers to the statistical destruction and removal of all living organisms.
- Disinfect refers to inanimate objects and the destruction of all vegetative cells (not spores).
- Sanitise refers to the reduction of microorganisms to levels considered safe from a public health viewpoint.

Appropriate and approved sanitisation procedures are processes and, thus, the duration or time as well as the chemical conditions must be described. The official definition (Association of Official Analytical Chemists) of sanitising for food product contact surfaces is a process

which reduces the contamination level by 99.999% (5 logs) in 30 sec. The official definition for non-product contact surfaces requires a contamination reduction of 99.9% (3 logs). The standard test organisms used are: *Staphylococcus aureus* and *Escherichia coli*.

General types of sanitisation include:

- Thermal Sanitisation involves the use of hot water or steam for a specified temperature and contact time.
- Chemical Sanitisation involves the use of an approved chemical sanitiser at a specified concentration and contact time.

Chemistry and Quality of Water

Water comprises approximately 95-99% of cleaning and sanitising solutions. Water functions to:

- carry the detergent or the sanitiser *to* the surface
- carry soils or contamination *from* the surface.

The impurities in water can drastically alter the effectiveness of a detergent or a sanitiser. Water hardness is the most important chemical property with a direct effect on cleaning and sanitising efficiency. (Other impurities can effect the food contact surface or may effect the soil deposit properties or film formation.)

Water pH ranges generally from pH 5 to 8.5. This range is of no serious consequence to most detergents and sanitisers. However, highly alkaline or highly acidic water may require additional buffering agents.

Water can also contain significant numbers of microorganisms. Water used for cleaning and sanitising must be potable and pathogen-free. Treatments and sanitisation of water may be required prior to use in

cleaning regimes. Water impurities which effect cleaning functions are presented in Table 1.

Table 1. Water impurities and associated problems.

Impurity	Problem Caused
<i>Common Impurities</i>	
Oxygen	Corrosion
Carbon Dioxide	Corrosion
Bicarbonates (Sodium, Calcium or Magnesium)	Scale
Chlorides or Sulfates (Sodium, Calcium or Magnesium)	Scale & Corrosion
Silica	Scale
Suspended Solids	Corrosion and Deposition
Unusually high pH (above 8.5)	Mediate Corrosion and Deposition; Alter detergent efficiency
Unusually low pH (below 5)	Mediate Corrosion and Deposition; Alter detergent efficiency
<i>Less Common Impurities</i>	
Iron	Filming and Staining
Manganese	Corrosion
Copper	Filming and Staining

Cleaning

Food soils

Food soil is generally defined as unwanted matter on

food-contact surfaces. Soil is visible or invisible. The primary source of soil is from the food product being handled. However, minerals from water residue and residues from cleaning compounds contribute to films left on surfaces. Microbiological biofilms also contribute to the soil buildup on surfaces. Since soils vary widely in composition, no one detergent is capable of removing all types.

Many complex films contain: combinations of food components, surface oil or dust, insoluble cleaner components, and insoluble hard-water salts. These films vary in their solubility properties depending upon such factors as heat effect, age, dryness, time, etc. It is essential that personnel involved have an understanding of the nature of the soil to be removed before selecting a detergent or cleaning regime.

The rule of thumb is that acid cleaners dissolve alkaline soils (minerals) and alkaline cleaners dissolve acid soils and food wastes. Improper use of detergents can actually "set" soils, making them more difficult to remove (e.g., acid cleaners can precipitate protein). Many films and biofilms require more sophisticated cleaners which are amended with oxidising agents (such as chlorinated detergents) for removal. Soils may be classified as:

- soluble in water (sugars, some starches, most salts);
- soluble in acid (limestone and most mineral deposits);
- soluble in alkali (protein, fat emulsions);
- soluble in water, alkali, or acid.

The physical condition of the soil deposits also affects its solubility. Freshly precipitated soil in a cool or cold solution is usually more easily dissolved than an old,

dried, or baked-on deposit, or a complex film. Food soils are complex in that they contain mixtures of several components. A general soil classification and removal characteristics is presented in Table 2.

Table 2. Characteristics of Food Soils

Surface Deposit	Solubility	Ease of Removal	Heat-Induced Reactions
Sugar	Water soluble	Easy	Carmelization
Fat	Alkali soluble	Difficult	
Polymerization			
Protein	Alkali soluble	Very Difficult	Denaturation
Starch	Water soluble, Alkali soluble	Easy to Moderately Easy	Interactions with other constituents
Monovalent	Water soluble; Salts Acid soluble	Easy to Difficult	Generally not significant
+Polyvalent Salts	Acid soluble	Difficult	Interaction with other constituents

Fat-based soils: Fat usually is present as an emulsion and can generally be rinsed away with hot water above the melting point. More difficult fat and oil residues can be removed with alkaline detergents which have good emulsifying or saponifying ingredients.

Protein-based soils: In the food industry, proteins are by far the most difficult soils to remove. In fact, casein (a major milk protein) is used for its adhesive properties in many glues and paints. Food proteins range from more simple proteins, which are easy to remove, to more

complex proteins, which are very difficult to remove. Heat-denatured proteins can be extremely difficult. Generally, a highly alkaline detergent with peptising or dissolving properties is required to remove protein soils. Wetting agents can also be used to increase the wettability and suspendability of proteins. Protein films require alkaline cleaners which have hypochlorite in addition to wetting agents.

Carbohydrate-based soils: Simple sugars are readily soluble in warm water and are quite easily removed. Starch residues, individually, are also easily removed with mild detergents. Starches associated with proteins or fats can usually be easily removed by highly alkaline detergents.

Mineral salt-based soils: Mineral salts can be either relatively easy to remove, or be highly troublesome deposits or films. Calcium and magnesium are involved in some of the most difficult mineral films. Under conditions involving heat and alkaline pH, calcium and magnesium can combine with bicarbonates to form highly insoluble complexes. Other difficult deposits contain iron or manganese. Salt films can also cause corrosion of some surfaces. Difficult salt films require an acid cleaner (especially organic acids which form complexes with these salts) for removal. Sequestering agents such as phosphates or chelating agents are often used in detergents for salt film removal.

Microbiological films: Under certain conditions, microorganisms (bacteria, yeasts, and molds) can form invisible films (biofilms) on surfaces. Biofilms can be difficult to remove and usually require cleaners as well as sanitisers with strong oxidising properties.

Lubricating greases and oils: These deposits (insoluble in water, alkali, or acid) can often be melted with hot water

or steam, but often leave a residue. Surfactants can be used to emulsify the residue to make it suspendable in water and flushable.

Other insoluble soils: Inert soils such as sand, clay, or fine metal can be removed by surfactant-based detergents. Charred or carbonised material may require organic solvents.

Soil quantity

It is important to rinse food-contact surfaces prior to cleaning to remove most of the soluble soil. Heavy deposits require more detergent to remove. Improper cleaning can actually contribute to build-up of soil.

Surface characteristics

The cleanability of the surface is a primary consideration in evaluating cleaning effectiveness. Included in surface characteristics are:

Surface Composition. Stainless steel is the preferred surface for food equipment and is specified in many industry and regulatory design and construction standards. For example: 3-A Sanitary Standards (equipment standards used for milk and milk products applications) specify 300 series stainless steel or equivalent. Other grades of stainless steel may be appropriate for specific applications (i.e. 400 series) such as handling of high fat products, meats, etc. For highly acidic, high salt, or other highly corrosive products, more corrosion resistant materials (i.e. titanium) is often recommended.

Other “soft” metals (aluminum, brass, copper, or mild steel), or nonmetallic surfaces (plastics, or rubber) are also used on food contact surfaces. Surfaces of soft metals and nonmetallic materials are generally less corrosion-

resistant and care should be exercised in their cleaning. Aluminum is readily attacked by acids as well as highly alkaline cleaners which can render the surface non-cleanable. Plastics are subject to stress cracking and clouding from prolonged exposure to corrosive food materials or cleaning agents. Hard wood (maple or equivalent) or sealed wood surfaces should only be used in limited applications such as cutting boards or cutting tables provided the surface is maintained in good repair. Avoid using porous wood surfaces.

Surface Finish. Equipment design and construction standards also specify finish and smoothness requirements. 3-A standards specify a finish at least as smooth as a No. 4 ground finish for most application. With high-fat products, a less smooth surface is used to allow product release from the surface.

Surface Condition. Misuse or mishandling can result in pitted, cracked, corroded, or roughened surfaces. Such surfaces are more difficult to clean or sanitise, and may no longer be cleanable. Thus, care should be exercised in using corrosive chemicals or corrosive food products.

Environmental considerations

Detergents can be significant contributors to the waste discharge (effluent). Of primary concern is pH. Many publicly owned treatment works limit effluent pH to the range of 5 to 8.5. So, it is recommended that in applications where highly alkaline cleaners are used, that the effluent be mixed with rinse water (or some other method be used) to reduce the pH. Recycling of caustic soda cleaners is also becoming a common practice in larger operations. Other concerns are phosphates, which are not tolerated in some regions of the U.S., and the overall soil load in the waste stream which contributes to

the chemical oxygen demand (COD) and biological oxygen demand (BOD).

Chemistry of detergents

Detergents and cleaning compounds are usually composed of mixtures of ingredients that interact with soils in several ways:

- Physically active ingredients alter physical characteristics such as solubility or colloidal stability.
- Chemically active ingredients modify soil components to make them more soluble and, thus, easier to remove.

In some detergents, specific enzymes are added to catalytically react with, and degrade, specific food soil components.

Physically active ingredients

The primary physically active ingredients are the surface active compounds termed surfactants. These organic molecules have general structural characteristic where a portion of the structure is hydrophilic (water- loving) and a portion is hydrophobic (not reactive with water). Such molecules function in detergents by promoting the physical cleaning actions through: emulsification, penetration, spreading, foaming, and wetting. The classes of surfactants are:

- Ionic surfactants which are negatively charged in water solution are termed *anionic* surfactants. Conversely, positively charged ionic surfactants are termed *cationic* surfactants. If the charge of the water soluble portion is depended upon the pH of the solution it is termed an *amphoteric* surfactant.

These surfactants behave as *cationic* surfactants under acid conditions, and as *anionic* surfactants under alkaline conditions. Ionic surfactants are generally characterised by their high foaming ability.

- Nonionic surfactants, which do not dissociate when dissolved in water, have the broadest range of properties depending upon the ratio of hydrophilic/ hydrophobic balance. This balance is also affected by temperature. *For example, the foaming properties of nonionic detergents is affected by temperature of solution. As temperature increases, the hydrophobic character and solubility decreases. At the cloud point (minimum solubility), these surfactants generally act as defoamers, while below the cloud point they are varied in their foaming properties.* It is a common practice to blend surfactant ingredients to optimise their properties. However, because of precipitation problems, *cationic* and *anionic* surfactants cannot be blended

Chemically active ingredients

Alkaline Builders: Highly Alkaline Detergents (or heavy-duty detergents) use caustic soda (sodium hydroxide) or caustic potash (potassium hydroxide). An important property of these highly alkaline detergents is that they saponify fats: forming soap. These cleaners are used in many CIP systems or bottle-washing applications. Moderately Alkaline Detergents include sodium, potassium, or ammonium salts of phosphates, silicates, or carbonates. Tri-sodium phosphate (TSP) is one of the oldest and most effective. Silicates are most often used as a corrosion inhibitor. Because of interaction with calcium and magnesium and film formation, carbonate-based

detergents are of only limited use in food processing cleaning regimes.

Acid Builders: Acid Detergents include organic and inorganic acids. The most common inorganic acids used include: phosphoric, nitric, sulfamic, sodium acid sulphate, and hydrochloric. Organic acids, such as hydroxyacetic, citric, and gluconic, are also in use. Acid detergents are often used in a two-step sequential cleaning regime with alkaline detergents. Acid detergents are also used for the prevention or removal of stone films (mineral stone, beer stone, or milk stone).

Water Conditioners: Water conditioners are used to prevent the build-up of various mineral deposits (water hardness, etc.). These chemicals are usually sequestering agents or chelating agents. Sequestering agents form soluble complexes with calcium and magnesium. Examples are sodium tripolyphosphate, tetra-potassium pyrophosphate, organo-phosphates, and polyelectrolytes. Chelating agents include sodium gluconate and ethylene diamine tetracetic acid (EDTA).

Oxidising Agents: Oxidising agents used in detergent application are hypochlorite (also a sanitiser) and—to a lesser extent—perborate. Chlorinated detergents are most often used to clean protein residues.

Enzyme Ingredients: Enzyme-based detergents, which are amended with enzymes such as amylases and other carbohydrate-degrading enzymes, proteases, and lipases, are finding acceptance in specialised food industry applications. The primary advantages of enzyme detergents are that they are more environmentally friendly and often require less energy input (less hot water in cleaning). Uses of most enzyme cleaners are usually limited to unheated surfaces (e.g., cold-milk surfaces). However, new generation enzyme cleaners

(currently under evaluation) are expected to have broader application.

Fillers: Fillers add bulk or mass, or dilute dangerous detergent formulations which are difficult to handle. Strong alkalis are often diluted with fillers for ease and safety of handling. Water is used in liquid formulations as a filler. Sodium chloride or sodium sulphate are often fillers in powdered detergent formulations.

Miscellaneous Ingredients: Additional ingredients added to detergents may include: corrosion inhibitors, glycol ethers, and butylcellosolve (improve oil, grease, and carbon removal).

Sanitising

Thermal Sanitising: As with any heat treatment, the effectiveness of thermal sanitising is dependant upon a number of factors including: initial contamination load, humidity, pH, temperature, and time.

Steam: The use of steam as a sanitising process has limited application. It is generally expensive compared to alternatives, and it is difficult to regulate and monitor contact temperature and time. Further, the byproducts of steam condensation can complicate cleaning operations.

Hot Water: Hot-water sanitising—through immersion (small parts, knives, etc.), spray (dishwashers), or circulating systems—is commonly used. The time required is determined by the temperature of the water. Typical regulatory requirements (Food Code 1995) for use of hot water in dishwashing and utensil sanitising applications specify: immersion for at least 30 sec. at 77°C (170°F) for manual operations; a final rinse temperature of 74°C (165°F) in single tank, single temperature machines and 82°C (180°F) for other machines.

Many state regulations require a utensil surface temperature of 71°C (160°F) as measured by an irreversibly registering temperature indicator in warewashing machines. Recommendations and requirements for hot-water sanitising in food processing may vary. The Grade A Pasteurised Milk Ordinance specifies a minimum of 77°C (170°F) for 5 min. Other recommendations for processing operations are: 85°C (185°F) for 15 min., or 80°C (176°F) for 20 min.

The primary advantages of hot-water sanitisation are: relatively inexpensive, easy to apply and readily available, generally effective over a broad range of microorganisms, relatively non-corrosive, and penetrates into cracks and crevices. Hot-water sanitisation is a slow process which requires come-up and cool-down time; can have high energy costs; and has certain safety concerns for employees. The process also has the disadvantages of forming or contributing to film formations, and shortening the life of certain equipment or parts thereof (gaskets, etc.).

Chemical Sanitising: The ideal chemical sanitiser should:

- be approved for food contact surface application
- have a wide range or scope of activity.
- destroy microorganisms rapidly.
- be stable under all types of conditions.
- be tolerant of a broad range of environmental conditions.
- be readily solubilised and possess some detergency.
- be low in toxicity and corrosivity.
- be inexpensive.

No available sanitiser meets all of the above criteria. Therefore, it is important to evaluate the properties, advantages, and disadvantages of available sanitiser for each specific application.

The regulatory concerns involved with chemical sanitisers are: antimicrobial activity or efficacy, safety of residues on food contact surfaces, and environmental safety. It is important to follow regulations that apply for each chemical usage situation. The registration of chemical sanitisers and antimicrobial agents for use on food and food product contact surfaces, and on nonproduct contact surfaces, is through the U.S. Environmental Protection Agency (EPA).

Prior to approval and registration, the EPA reviews efficacy and safety data, and product labelling information. The U.S. Food and Drug Administration (FDA) is primarily involved in evaluating residues from sanitiser use which may enter the food supply. Thus, any antimicrobial agent and its maximum usage level for direct use on food or on food product contact surfaces must be approved by the FDA.

Approved no-rinse food contact sanitises and nonproduct contact sanitisers, their formulations and usage levels are listed in the *Code of Federal Regulations* (21 CFR 178.1010). The U.S. Department of Agriculture (USDA) also maintains lists of antimicrobial compounds (i.e., *USDA List of Proprietary Substances and Non Food Product Contact Compounds*) which are primarily used in the regulation of meats, poultry, and related products by USDA's Food Safety and Inspection Service (FSIS.).

Effects of factors on sanitising

1. Physical factors

- *Surface Characteristics.* Prior to the sanitisation process, all surfaces must be clean and thoroughly rinsed to remove any detergent residue. An unclean surface cannot be sanitised. Since the effectiveness of sanitisation requires direct contact with the microorganisms, the surface should be free of cracks, pits, or crevices which can harbour microorganisms. Surfaces which contain biofilms cannot be effectively sanitised.
- *Exposure Time.* Generally, the longer time a sanitiser chemical is in contact with the equipment surface, the more effective the sanitisation effect; intimate contact is as important as prolonged contact.
- *Temperature.* Temperature is also positively related to microbial kill by a chemical sanitiser. Avoid high temperatures (above 55°C [131°F]) because of the corrosive nature of most chemical sanitisers.
- *Concentration.* Generally, the activity of a sanitiser increases with increased concentration. However, a levelling off occurs at high concentrations. A common misconception regarding chemicals is that “if a little is good, more is better”. Using sanitiser concentrations above recommendations does not sanitise better and, in fact, can be corrosive to equipment and in the long run lead to less cleanability. Follow manufacturer’s label instructions.
- *Soil.* The presence of organic matter dramatically reduces the activity of sanitisers

and may, in fact, totally inactivate them. The adage is “you cannot sanitise an unclean surface”.

2. Chemical factors

- *pH*. Sanitisers are dramatically affected by the pH of the solution. Many chlorine sanitisers, for example, are almost ineffective at pH values above 7.5.
- *Water properties*. Certain sanitisers are markedly affected by impurities in the water.
- *Inactivators*. Organic and/or inorganic inactivators may react chemically with sanitisers giving rise to non-germicidal products. Some of these inactivators are present in detergent residue. Thus, it is important that surfaces be rinsed prior to sanitisation.

3. Biological factors: The microbiological load can affect sanitiser activity. Also, the type of microorganism present is important. Spores are more resistant than vegetative cells. Certain sanitisers are more active against gram positive than gram negative microorganisms, and vice versa. Sanitisers also vary in their effectiveness against yeasts, molds, fungi, and viruses.

Chemical Sanitisers

The chemicals described here are those approved by FDA for use as no-rinse, food-contact surface sanitisers. In food-handling operations, these are used as rinses, sprayed onto surfaces, or circulated through equipment in CIP operations. In certain applications the chemicals are foamed on a surface or fogged into the air to reduce airborne contamination.

Chlorine-based sanitisers

Chlorine Compounds: Chlorine, in its various forms, is the most commonly used sanitiser in food processing and handling applications. Commonly used chlorine compounds include: liquid chlorine, hypochlorites, inorganic chloramines, and organic chloramines. Chlorine-based sanitisers form hypochlorous acid (HOCl , the most active form) in solution. Available chlorine (the amount of HOCl present) is a function of pH. At pH 5, nearly all is in the form of HOCl . At pH 7.0, approximately 75% is HOCl .

The maximum allowable level for no-rinse applications is 200ppm available chlorine, but recommended usage levels vary. For hypochlorites, an exposure time of 1 min at a minimum concentration of 50ppm and a temperature of 24°C (75°F) is recommended. For each 10°C (18°F) drop in temperature, a doubling of exposure time is recommended. For chloramines, 200ppm for 1 min is recommended.

Chlorine compounds are broad spectrum germicides which act on microbial membranes, inhibit cellular enzymes involved in glucose metabolism, have a lethal effect on DNA, and oxidise cellular protein. Chlorine has activity at low temperature, is relatively cheap, and leaves minimal residue or film on surfaces. The activity of chlorine is dramatically affected by such factors as pH, temperature, and organic load. However, chlorine is less affected by water hardness when compared to other sanitisers (especially the quaternary ammonium compounds).

The major disadvantage to chlorine compound is corrosiveness to many metal surfaces (especially at higher temperatures). Health and safety concerns can occur due to skin irritation and mucous membrane damage in

confined areas. At low pH (below 4.0), deadly Cl_2 (mustard gas) can form. In recent years, concerns have also been raised about the use of chlorine as a drinking water disinfectant and as an antimicrobial with direct food contact (meat, poultry and shellfish). This concern is based upon the involvement of chlorine in the formation of potentially carcinogenic trihalomethanes (THMs) under appropriate conditions. While chlorine's benefits as a sanitiser far outweigh these risks, it is under scrutiny.

Chlorine dioxide: Chlorine dioxide (ClO_2) is currently being considered as a replacement for chlorine, since it appears to be more environmentally friendly. Stabilised ClO_2 has FDA approval for most applications in sanitising equipment or for use as a foam for environmental and non-food contact surfaces. Approval has also been granted for use in flume waters in fruits and vegetable operations and in poultry process waters. ClO_2 has 2.5 times the oxidising power of chlorine and, thus, less chemical is required. Typical use concentrations range from 1 to 10ppm.

ClO_2 's primary disadvantages are worker safety and toxicity. Its highly concentrated gases can be explosive and exposure risks to workers is higher than that for chlorine. Its rapid decomposition in the presence of light, or at temperatures greater than 50°C (122°F) makes on-site generation a recommended practice.

Iodine

Use of iodine as an antimicrobial agents dates back to the 1800s. This sanitiser exists in many forms and usually exists with a surfactant as a carrier. These mixtures are termed iodophors. The most active agent is the dissociated free iodine (also less stable). This form is most prevalent at low pH. The amount of dissociation from the surfactant is dependent upon the type of surfactant.

Iodine solubility is very limited in water. Generally recommended usage for iodophors is 12.5 to 25ppm for 1 min.

It is generally thought that the bactericidal activity of iodine is through direct halogenation of proteins. More recent theories have centered upon cell wall damage and destruction of microbial enzyme activity. Iodophors, like chlorine compounds, have a very broad spectrum: being active against bacteria, viruses, yeasts, molds, fungi, and protozoans. Iodine is highly temperature-dependent and vaporises at 120°F. Thus, it is limited to lower temperature applications. The degree to which iodophors are affected by environmental factors is highly dependant upon properties of the surfactant used in the formulation.

Iodophors are generally less affected by organic matter and water hardness than chlorine. However, loss of activity is pronounced at high pH. Iodine has a long history of use in wound treatment. However, ingestion of iodine gas does pose a toxicity risk in closed environments. The primary disadvantage is that iodine can cause staining on some surfaces (especially plastics).

Quaternary Ammonium Compounds (QACs)

Quaternary ammonium compounds (QACs) are a class of compounds which have the general structure as follows (Figure 1):

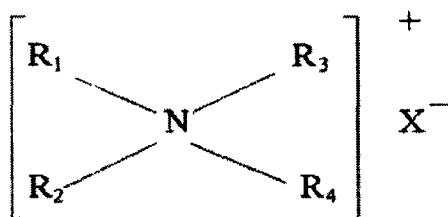


Figure 1. Quaternary ammonium compounds

The properties of these compounds depend upon the covalently bound alkyl groups (R groups), which can be highly diverse. Since QACs are positively charged cations, their mode of action is related to their attraction to negatively charged materials such as bacterial proteins. It is generally accepted that the mode of action is at the membrane function. The carbon length of R-group side chain is, generally, directly related with sanitiser activity in QACs. However, because of the lower solubility in QACs composed of large carbon chains, these sanitisers may have lower activity than short chain structures.

QACs are active and stable over a broad temperature range. Because they are surfactants, they possess some detergency. Thus, they are less affected by light soil than are other sanitisers. However, heavy soil dramatically decreases activity. QACs generally have higher activity at alkaline pH. While lack of tolerance to hard water is often listed as a major disadvantage of QACs when compared to chlorine, some QACs are fairly tolerant of hard water. Activity can be improved by the use of EDTA as a chelator. QACs are effective against bacteria, yeasts, mold, and viruses.

An advantage of QACs in some applications is that they leave a residual antimicrobial film. However, this would be a disadvantage in operations such as cultured dairy products, cheese, beer, etc. where microbial starter cultures are used. QACs are generally more active against gram positive than gram negative bacteria. They are not highly effective against bacteriophages. Their incompatibility with certain detergents makes thorough rinsing following cleaning operations imperative. Further, many QAC formulations can cause foaming problems in CIP applications.

Under recommended usage and precautions, QACs pose little toxicity or safety risks. Thus, they are in common use as environmental fogs and as room deodorisers. However, care should be exercised in handling concentrated solutions or use as environmental fogging agents.

Acid-anionic sanitisers

Like QACs, acid-anionic sanitisers are surface- active sanitisers. These formulations include an inorganic acid plus a surfactant, and are often used for the dual function of acid rinse and sanitisation. Whereas QACs are positively charged, these sanitisers are negatively charged. Their activity is moderately affected by water hardness. Their low use pH, detergency, stability, low odor potential, and non-corrosiveness makes them highly desirable in some applications. Disadvantages include: relatively high cost, a closely defined pH range of activity (pH 2 to 3), low activity on molds and yeasts, excessive foaming in CIP systems, and incompatibility with cationic surfactant detergents.

Fatty acid sanitisers

Fatty acid or carboxylic acid sanitisers were developed in the 1980s. Typical formulations include fatty acids plus other acids (phosphoric acids, organic acids). These agents also have the dual function of acid rinse and sanitisation. The major advantage over acid anionics is lower foaming potential. These sanitisers have a broad range of activity, are highly stable in dilute form, are stable to organic matter, and are stable to high temperature applications.

These sanitisers have low activity above pH 3.5 - 4.0, are not very effective against yeasts and molds, and some

formulations lose activity at temperatures below 10°C (50°F). They also can be corrosive to soft metals and can degrade certain plastics, or rubber.

Peroxides

Peroxides or peroxy compounds contain at least one pair of covalently bonded oxygen atoms (-O-O-) and are divided into two groups: the inorganic group, containing hydrogen peroxide (HP) and related compounds; and the organic group, containing peroxyacetic acid (PAA) and related compounds.

Hydrogen peroxide (HP), while widely used in the medical field, has found only limited application in the food industry. FDA approval has been granted for HP use for sterilising equipment and packages in aseptic operations. The primary mode of action for HP is through creating an oxidising environment and generation of singlet or superoxide oxygen (SO). HP is fairly broad spectrum with slightly higher activity against gram-negative than gram-positive organisms. High concentrations of HP (5% and above) can be an eye and skin irritant. Thus, high concentrations should be handled with care.

Peroxyacetic Acid (PAA) has been known for its germicidal properties for a long time. However, it has only found food-industry application in recent years and is being promoted as a potential chlorine replacement. PAA is relatively stable at use strengths of 100 to 200ppm. Other desirable properties include: absence of foam and phosphates, low corrosiveness, tolerance to hard water, and favourable biodegradability. PAA solutions have been shown to be useful in removing biofilms.

While precise mode of action mechanisms have not been determined, it is generally theorised that the PAA reaction with microorganisms is similar to that of HP. PAA, however, is highly active against both gram-positive and gram-negative microorganisms. The germicidal activity of PAA is dramatically affected by pH. Any pH increase above 7-8 drastically reduces the activity. PAA has a pungent odor and the concentrated product (40%) is a highly toxic, potent irritant, and powerful oxidiser. Thus, care must be used in its use.

5

Food Storage

There are any number of food storage plans to be found by those who take the time to look. Many of them are based on the so-called "Mormon Four" of wheat, milk, honey and salt, with as many additional foods as the planner finds to be desirable. An unfortunate number of people in our society have developed allergies to one kind of food or another.

One of the more common food allergens is wheat. Even more unfortunate is the fact that of those with an allergy to this most common of grains, many of them are not even aware of it. They won't become aware of it until they try to live with wheat as a large part of their diet. This is the reason you should store what you eat and eat what you store: So that ugly surprises such as this don't come up when it's too late to easily avoid them.

A second reason to think about providing a variety of grains in your food storage is appetite fatigue. There are many people who think providing variety in the diet is relatively unimportant and that if and when the time comes they'll eat what they've got and that will be that. For healthy, well-adjusted adults under ordinary circumstances this might be possible without too much difficulty. However, the entire reason for having a *long*

term food storage programme is for when circumstances *aren't* ordinary.

Times of crisis produce stress—possibly physical, but always mental. If you are suddenly forced to eat a diet that is both alien and monotonous, it is going to add just that much more stress on top of what you are already dealing with. If your planning includes the elderly, young children and infants they might just quit eating or refuse to eat sufficient amounts and become unable to survive. This is not a trivial problem and should be given serious consideration. Consider the positive aspects of adding some “comfort foods”.

Wheat

Wheat comes in a number of different varieties. Each variety is more or less suitable for a given purpose based on its characteristics. The most common classifications for wheat varieties are spring or winter, hard or soft, red or white. The hard wheats have kernels that tend to be small, very hard and have a high gluten content. Gluten is the protein in grains that enables the dough made from them to trap the gasses produced by yeast fermentation and raise the bread. Low gluten wheat does not produce as good a loaf as high gluten wheat, though they can still be used for yeast breads if necessary. As a general rule, hard varieties have more protein than soft varieties.

The soft varieties have kernels tending to be larger, plumper and softer in texture than hard wheats. Their gluten content is less and these are used in pastries, quick breads, pastas, and breakfast cereals. Winter wheats are planted in the fall, over winter in the field and are harvested the next summer. Spring wheats are planted in the early spring and are harvested in the fall. Red wheats comprise most of the hard varieties while white wheats

comprise most of the soft. Recently, hard white wheats have been developed that are suitable for raised bread making.

Some feel the hard white varieties make a better tasting whole wheat bread than the hard red. The most commonly stored are the hard red varieties, either spring or winter, because of their high protein. They should have a protein content of no less than 12%, with higher the better. The hard white spring wheats are still relatively new and are not yet widespread. They have the same excellent storage characteristics as the hard red wheats.

Amaranth

Amaranth is not a true cereal grain at all, but is a relative of the pigweeds and the ornamental flowers we know as cockscomb. It's grown not only for its seeds, but for its leaves that can be cooked and eaten as greens. The grain is high in protein, particularly the amino acid lysine which is limited in the true cereal grains. The grains can be milled as-is, or the seeds can be toasted to provide more flavour. The flour lacks gluten, so it's not suited for raised breads, but can be made into any of a number of flat breads. Some varieties can be popped much like popcorn, or can be boiled and eaten as a cereal, used in soups, granolas, and the like. Toasted or untoasted, it blends well with other grain flours.

Barley

Barley is thought by some to be the first grain ever grown by man. It has short, stubby kernels with a hull that is difficult to remove. Excluding barley intended for malting or animal feed, most of this grain is consumed by humans in two forms. The most common is the white,

highly processed "pearl" barley that has had most of its bran and germ milled off along with its hull. It is the least nutritious form of barley. The second form it's found in is called "pot" or "hulled" barley and it has been subjected to the same milling process as pearled, but with fewer trips through the polisher. Because of this, it retains more of the nutritious germ and bran.

Barley can be milled into flour, but its low gluten content will not make a good loaf of raised bread. It can be combined with other flours that have sufficient gluten to make good raised bread or used in flat breads. Barley flour and flakes have a light nutty flavour that is enhanced by toasting. Whole barley is commonly used to add thickness to soups and stews. Recently, a hull-less form of barley has become available on the market through a few suppliers. This is whole grain barley with all of its bran and germ intact and should have the most nutrients of any form of this grain available.

Buckwheat

Buckwheat is another of those seeds commonly considered to be a grain, but which is not a true cereal. It is a close relative to the docks and sorrels. The grain itself is a dark, three cornered seed resembling a tiny beechnut. It has a hard, fibrous hull that requires a special buckwheat huller to remove it. Here in the U.S., it is most often used in pancakes, biscuits and muffins. In eastern Europe and Russia it is known in its toasted form as kasha. In the Far East, it's often made into soba or noodles. It's also a good bee plant, producing a dark, strongly flavoured honey. The flour is light or dark depending on how much of the hull has been removed before grinding.

Dark flour is far superior nutritionally as you might expect, but it also much more strongly flavoured.

Buckwheat is one of those foods with no middle ground in peoples opinions—they either love it or they hate it. Like amaranth, it's high in lysine, an amino acid commonly lacking in the true cereal grains.

Corn

Corn is the most common grain crop in the U.S., but it is mostly consumed indirectly as animal feed or even industrial feedstock rather than directly as food. Nevertheless, it comes in an amazing variety of forms and, like wheat, some of them are better suited for a particular purpose than others. The varieties intended to be eaten as fresh, green corn are very high in sugar content and do not dry or store well. The other varieties are the flint, dent, and popcorns. All of them keep well when they have been properly dried.

To a certain extent, they're all interchangeable for purposes of grinding into meal (sometimes known as polenta meal) or flour (very finely ground corn, not cornstarch), but some make better meal than flour and vice versa. As a general rule of thumb, the flint varieties make better meal as they have a grittier texture than the dent corns which make better flour. If meal, hominy and hominy grits (commonly called just "grits") are what you are most interested in, use the flint type. If you intend to make corn masa for tortillas and tamales, then the dent type is what you want.

Popcorn is what you need if you want to pop it for snacks and it can also be ground into meal or flour. Yellow dent corn seems to be the most commonly available variety among storage food dealers. Popcorn is one form of a whole grain available to nearly everyone in the U.S. if they know where to look. Since it's so popular as a snack food, particularly in movie theaters and events

like fairs and ball games, even the smallest of towns will generally have at least one business selling it in twenty five or fifty pound bags. Since it's meant to be eaten it's safe for food.

To be at its most poppable, this corn needs to have a moisture content between 13.5%-15.5% which makes it just a little too moist for ideal storage. A small amount of drying will need to be done before it's packed away. If wanted for popping later, it can always be re-hydrated by sprinkling a small amount of water on the kernels, shaking vigorously and allowing it to be absorbed.

Once you've decided between flint, dent or popcorn, you now have to decide upon it's colour: There are yellow, white, blue, & red dried varieties. The yellow and white types are the most common by far with the blues and reds mostly being relegated to curiosities, though blue corn has been gaining in popularity these last few years. It should be kept in mind that white corn does not have the carotene (converts into vitamin A) content of yellow corn.

Millet

Millet is an important staple grain in North China, and India, but is little known as a food in the U.S, mostly being used as bird feed. The grain kernels are very small, round, and usually ivory coloured or yellow, though some varieties are darker. The lack of gluten and a rather bland flavour may account for the anonymity of this grain here, but it's alkaline content is higher than other grains and makes it very easy to digest. It also has a higher iron content than any other grain but amaranth. It swells a great deal when cooked and supplies more servings per pound than any other grains. When cooked like rice it makes an excellent breakfast cereal. Though it

has little gluten of its own, it mixes well with other flours.

Oats

Though the Scots and the Irish have made an entire cuisine from oats, they are still mostly thought of in the U.S. as a bland breakfast food. It is seldom found as a whole grain, usually being sold processed in one form or another. Much like barley, oats are a difficult grain to separate from their hulls. Besides their longtime role as a breakfast food, where they can be made very flavourful with a little creative thought, oats make an excellent thickener of soups and stews and a filler in meat loafs and casseroles. Probably the second most common use for oats in America is in cookies and granolas. Listed below in order of desirability for storage are the forms of oats most often found in this country. Rolled and cut oats retain both their bran and their germ.

Oat Groats: These are whole oats with the hulls removed. They are not often found in this form, but can sometimes be had from natural food stores and some storage food dealers. Oats are not the easiest thing to get a consistent grind from so producing your own oat flour takes a bit of experience.

Steel Cut Oats: Also known as Irish or pinhead or porridge (but so are rolled) oats. These are oat groats which have been cut into chunks with steel blades. They're not rolled and look like coarse bits of grain. This form can be found in both natural food stores (sometimes *much* cheaper) and many supermarkets.

Rolled Oats: These are also commonly called "old fashioned", "thick cut" or "porridge" oats. To produce them, oat groats are steamed and then rolled to flatten.

They can generally be found wherever oats are sold. They take longer to cook than do the quick cooking oats, but they retain more flavour and nutrition. This is what most people will call to mind when they think of oatmeal.

Quick Cooking Rolled Oats: These are just steamed oat groats rolled thinner than the old fashioned kind above so that they will cook faster. They can usually be found right next to the thicker rolled oats.

Instant Rolled Oats: These are the "just add hot water" or microwave type of oat cereals and are not at all suited for a long term food storage programme. They do, however, have uses in "bug out" and 72 hour food kits for short term crises.

Whole Oats: This is with the hulls still on. They are sold in seed stores and sometimes straight from the farmer who grew them. If you do buy from a seed supplier, make certain that they have not been treated with any chemicals that are toxic to humans.

Quinoa

Quinoa is yet another of the grains that is not a true cereal. It's botanical name is *Chenopodium quinoa* (pronounced "keen-wah"), and is a relative of the common weed Lambsquarter. The individual kernels are about 1.5-2 mm in size and are shaped rather like small flattened spheres, yellow in colour. When quinoa is cooked, the germ of the grain coils into a small "tail" that lends a pleasant crunch. This exotic grain should be thoroughly washed before cooking in order to prevent the cooked product from tasting bitter. There are several varieties of quinoa that have colour ranging from near white to a dark brown. The larger white varieties are considered superior and are the most common found.

Rice

Rice is the most commonly consumed food grain in the world. Much like wheat and corn, rice comes in a number of varieties, each with different characteristics. They are typically divided into classes by the length of their kernel grains; short, medium and long.

Short Grain Rice: Short grain rice is a little softer and bit moister when it cooks and tends to stick together more than the longer rices. It has a sweeter, somewhat stronger flavour than long grain rice.

Medium Grain Rice: Medium grain rice is not very common in the States. It has flavour like short grain rice, but with a texture more like long grain rice.

Long Grain Rice: Long grain rice cooks up into a dryer, flakier dish than the shorter grains and the flavour tends to be blander. It is the most commonly found size of rice on the grocery shelves. Each of these may be processed into brown, white, parboiled or converted and instant rices. Different types of rices are:

Brown Rice: This is whole grain rice with only the hull removed. It retains all of the nutrition to be found in rice and has a pleasant nutty flavour when boiled. From a nutrition standpoint it is by far the best of the rices to put into storage, but it has one flaw: The essential oil in the germ of the rice is very susceptible to oxidation and soon goes rancid. As a result, brown rice has a shelf life of only about six months from the date of purchase unless given special packaging or storage processing. Freezing or refrigeration will greatly extend its storage life. It's also possible to purchase brown rice from long term food suppliers specially packaged in air tight containers with an inert nitrogen atmosphere. In this kind of packaging, (if properly done), the storage life of brown rice can be extended for years.

Converted Rice: Converted rice starts as brown rice which undergoes a process of soaking and steaming until it is partially cooked. It is dried and then polished to remove the bran and germ. The steaming process drives some of the vitamins and minerals from the outer layers into the white inner layers. This makes it more nutritious than polished white rice, but also makes it more expensive.

White Rice: This is raw rice that has had its outer layers milled off, taking with it about 10% of its protein, 85% of its fat and 70% of its mineral content. Because so much of the nutrition of the rice is lost, white rice sold in this country has to be enriched with vitamins that only partially replaces what was removed.

Rye

Rye is a well known bread grain in the U.S., though not as popular as wheat. It has dark brown kernels longer and thinner than wheat, but less gluten. Bread made from this grain tends to be somewhat dense unless gluten is added (often in the form of a lot of wheat flour) with colour that ranges from pale to dark brown. German pumpernickel, made with unrefined rye flour and molasses, is the blackest, densest form. Rye makes for excellent variety in the diet.

Sorghum

Sorghum is probably more widely known here in the States for the syrup made from the juice squeezed from the canes of one of its many varieties. Also widely called "milo", it is one of the principle cereal grains grown in Africa. Its seeds are somewhat round, a little smaller than peppercorns, with an overall brown colour with a bit of red and yellow mixed in. The varieties called "yellow

endosperm sorghum" have a better taste. Sorghum is a major feed grain in the Southwestern part of the U.S. and is where the vast majority of the national milo production goes to. Like most of the other grains, sorghum is low in gluten, but the seeds can be milled into flour and mixed with higher gluten flours or made into flat breads, pancakes or cookies. In the Far East, it is cooked and eaten like rice, while in Africa it is ground in meal for porridge. It's also commonly brewed into alcoholic beverages.

Legume Varieties

Unless a person is willing to spend a great deal of money on preserved meats, a food storage programme not including a quantity of legumes is simply incomplete. There are few non-animal foods that contain the amount of protein to be found in dried beans, peas, and lentils. The varieties commonly available in this country have protein contents ranging from 20%-35%. As with most non-animal proteins, they are not complete in themselves for purposes of human nutrition, but become so when they are combined with the incomplete proteins found in grains. It is for this reason that grains and legumes are so often mentioned together.

In cultures all over the world, it is common to find the two served together at a meal, making a complete protein, even when those doing the serving have no understanding of nutrition at all. The legume family, of which all beans, peas, lentils, and peanuts are a part of, is one of the largest in the plant kingdom. Because of this and the many thousands of years of development and cultivation that man has given them, the variety of edible legumes available to us is huge. Both the appearance and the names of legume varieties are colourful and varied.

The names range from "adzuki" beans, a type of soybean from the Orient, to "zipper" peas, a commonly found field pea here in the Southern U.S. The colour of the beans can range from a clean white, to deep red, dull green to flat black with thousands of mixtures and patterns of colours. In spite of this incredible variety of names and colours, legumes are largely interchangeable in cooking usage, although some dishes just wouldn't be the same if a different type was used. Below is a partial list of some of the more commonly eaten bean varieties.

Black Beans: Also known as turtle beans, these small, dark-brownish black, oval-shaped beans are well known in Cuban black bean soup. They are very commonly used in Central and South America and in China. They tend to bleed very darkly when cooked so they are not well suited to being combined with other beans, lest they give the entire pot a muddy appearance.

Black-eyed Pea: Although there is tremendous variation among the many varieties of field peas eaten throughout the Southern United States, it is black-eyed peas that are the most commonly known nationwide. The colouring of field peas is as varied as the rest of the legume family, with black-eyed peas being small and oval-shaped with an overall creamy colour and, of course, their distinctive black-eye. Dried field peas cook very quickly and combine very tastily with either rice or cornbread.

Chickpeas: Also known as the garbanzo bean or ceci pea (or bean), it tends to be a creamy or tan colour, rather lumpily roundish and larger than dried garden peas. Many have eaten chickpeas, even if they've never seen a whole one. They are the prime ingredient in hummus and falafel and are one of the oldest cultivated legume species known, going back as far as 5400 B.C. in the Near East.

Kidney Beans: Just like the rest of the family, kidney beans can be found in wide variety. They come in both light and dark red colour in their distinctive kidney shape. Probably best known here in the U.S. for their use in chili, they figure prominently in Mexican, Brazilian and Chinese cuisine.

Lentils: Lentils are an odd lot. They don't fit in with either the beans or the peas and occupy a place by themselves. Their shape is different from the other legumes being roundish little discs with colours ranging from muddy brown, to green to a rather bright orangish-red. They cook very quickly compared to the larger beans and have a distinctive flavour. They are much used in Far Eastern cuisine from Indian to Chinese.

Lima Beans: In the Southern U.S., they are also commonly called butter beans. They are one of the most common beans found in this country in all manner of preservation from the young small beans to the large fully mature type. Their flavour is pleasant, but a little bland. Their shape is rather flat and broad with colours ranging from pale green to speckled cream and purple.

Peanuts: The peanut, commonly known outside the U.S. as the groundnut, is not actually a nut at all, but a legume. Peanuts are another odd species not much like the more familiar beans and peas. Whatever their classification they are certainly not unfamiliar to U.S. eaters. Peanuts have a high protein percentage and even more fat. They are one of the two legume species commonly grown for oilseed in this country, and are also used for peanut butter, boiled and roasted peanuts. Many Central and South American, African and Chinese dishes incorporate peanuts so they are useful for much more than just a snack food or cooking oil.

Pinto Beans: Anyone who has eaten Tex-Mex food has probably had the pinto bean. It is one of the most commonly eaten beans in the U.S., particularly in the Southwestern portion of the country. Stereotypically bean shaped, it has a dappled pattern of tans and browns on its shell. Pintos have a flavour that blends well with many foods.

Soybeans: An entire university could be founded on the culinary and industrial uses of the soybean. It is by far the legume with the highest protein content in commercial production as well as being the other legume oilseed producer alongside the peanut. The beans themselves are small, and round with a multitude of different shades.

Soybean products range from tofu, to tempeh, to textured vegetable protein and hundreds of other uses. Although they are very high in protein, they don't lend themselves well to just being boiled until done and eaten the way other beans and peas do. For this reason, if you plan on keeping some as a part of your storage programme (and you should) you would be well served to begin to learn how to process and prepare them *now* when you're not under pressure to produce. That way you can throw out your mistakes and order pizza, rather than having to choke them down, regardless.

Grains and Legumes

Grains and legumes of all types may be purchased in a number of different fashions depending largely on where you live and the time of year. If you should happen to live in the area where the type of grain or legume that you are interested in purchasing is grown you may be able to purchase direct from the producer or distributor. If you are interested in doing this, you may be able to find what you want at any processing step along the way.

The most basic form is called "field run" which means that it's been harvested and sold shortly thereafter. It will not have been given any cleaning or processing and is likely to be rather dirty depending upon the conditions under which it was grown and harvested. A second basic form called "field run from storage" is grain that has been harvested and then put into storage for a time. It will have all of the dirt and detritus of field run grain and whatever it may have picked up from the silo as well.

If you want cleaner grain you should look for "pre-cleaned" which means that it has been passed through fans, screens or sieves to remove chaff, smut balls, insect parts, mouse droppings and other debris. For those of us who don't live in an area that produces the grain and legumes that we're interested in, we have to resort to the last type which is "pre-cleaned and pre-packaged". This is grain that's been harvested, cleaned and put up in bags or other containers-possibly even going so far as to already be packaged for long term storage.

Each of the above types of availability has its good and bad points. As you might expect, the more processing the product receives, the higher its price is likely to be. If you don't mind doing a little cleaning and you need to be frugal with your cash, then field run grain is the way to go. This is not *necessarily* the case when you purchase your grains or legumes direct from the farmer or elevator operator as field run or field run from storage grain. Nor is it necessarily the case if you've made the decision to utilise grains marketed as animal feed. Inspection procedures vary from nation to nation, so outside of the U.S. inquire of your supplier.

If you are buying your grains and legumes from some-place other than a food store then you need to know the history of what it is you are buying. Straight

field run grain, other than being dirty, is not likely to have had anything added to it that would make it undesirable for human consumption. There is, however, the small possibility it may have been infected with molds that would make it unsafe for eating. Field run from storage and any grade of grain not specifically advertised for human consumption may have had fumigants, fungicides or insecticides not certified as safe for human foods added to it while it was in the bin. It is important to know what it has been treated with before you buy it.

There is a fungal infection of grain called "ergot". It is attracted to rye more so than other grains, particularly if the growing conditions were damp where it was grown. This fungus causes a nervous disorder known as St. Anthony's Fire. When eaten in large quantities the ergot alkaloids can cause constriction of the blood vessels, particularly in the extremities. The effects of ergot poisoning are cumulative and lead to numbness of the limbs and other, frequently serious symptoms. This fungal disease affects only the flowering parts of some members of the grass family, mostly rye.

The fungus bodies are hard, spur like, purple black structures that replace the kernel in the grain head. The ergot bodies can vary in size from the length of the kernel to as much as several times as long. They don't crush as easily as smut bodies of other funguses. When they are cracked open, the inner broken faces are can be off-white, yellow, or tan. The infected grain looks very different from ordinary, healthy rye grains and can be spotted easily. Ergot only rarely affects other grains. If you purchase field run rye, you should closely examine it first for the presence of ergot bodies. If you find more than a very few, pass up that grain and look elsewhere.

Sometimes grain in the form of animal feed or seed grain/legumes is available. Keep in mind animal feeds may have a higher contaminant level than what is permissible for human consumption. Under certain circumstances, the USDA allows the sale of grain or legumes for animal feed that could not be sold for direct human consumption. If that feed is to be fed to non-lactating (non-dairy animals), they will sometimes allow an aflatoxin (a type of fungal mycotoxin) content of five times what is permissible for use in human foodstuffs.

It may even be mixed varieties of one grain and not all one type. Seed grains, in particular, must be investigated carefully to find out what they may have been treated with. It is quite common for seed to have had fungicides applied to them, and maybe other chemicals as well. If you do purchase field run grain of any sort, examine it closely for contamination and moldy grain. Ask the farmer or distributor whether it has been tested for mold or mycotoxin content. This is especially the case if you are buying field-run CORN, RYE, SOYBEANS or RICE. When you purchase direct from the field, you may be getting it before it has been checked. Be certain of what it is that you are getting and ask questions if you choose to go this route. Know who you are dealing with.

The moisture content of the grain or legume you want to purchase or grow has a major impact on how long you will be able to store it and have it remain nutritious and edible. The outside of each and every kernel of grain or bean you buy or grow may host thousands of fungi spores and bacteria. This is all perfectly natural and is not a reason to panic.

The problem lies in that at moisture levels between 13.5% to 15% some fungal species are able to grow and

reproduce. Other species require a moisture level in the 16-23% range. Aerobic bacteria (oxygen using) require a moisture level of about 20%. Raw peanuts are particularly susceptible to *Aspergillus* mold growth that produces aflatoxin and should be stored with an 8% moisture content or less. Thus, if you have grain you want to store with a moisture content as high as 12% you are perilously close to having enough moisture to enable mold growth which could lead to the ruin of your grain.

If you do not have a clue as to what the moisture level of your grain is here is a rough method to determine it. Take 20 ounces of the grain or legumes in question from the middle of its bag or container (this needs to be an actual weighed twenty ounces and not estimated). Spread the grain in a large baking dish making sure it is not more than an inch deep.

Heat at 180 F for about two hours, stirring occasionally. Allow the grain to cool where it won't reabsorb moisture, the oven will do. Once cool, reweigh the grain. A one ounce loss in weight indicates the grain had roughly a five percent moisture content, 2 ounces indicates that it has a 10% moisture content, etc, etc.

Cleaning

If you've chosen to purchase field-run grain or if the pre-cleaned product you've bought isn't clean enough to suit you, you can do it yourself. The fastest and easiest method is "fanning", a form of winnowing. This is done by pouring the grain slowly through the air stream of a fan or blower into a clean, deep container such as a cardboard box or trash can. The wind blowing through the falling grain will blow out most of the broken kernels, chaff, smut balls, mouse droppings, etc.

If you're losing too much good grain, try turning the fan down or moving it further back from the container. The deep container will cut down on the amount of kernels that bounce out. Repeat fanning as necessary until the grain is clean enough to suit or you've blown all of the lighter contaminants out. If the fanning didn't get the grain clean enough then it can be further cleaned by running it through a screen or sieve. This should be made with holes just big enough to pass an average sized grain of what it is you're cleaning. Obviously, the size of the holes will necessarily vary depending upon the kernel size of the grain.

Should the kernels still not be clean enough to suit then you'll just have to resort to "hand picking" out the offending particles. If you have it in mind to wash the grain, this should not be done prior to storage, but, rather, just before use. After it's been rinsed, it should be dried immediately in the oven by placing it no deeper than 1/2 inch and heated at 150 F for an hour. It should be stirred occasionally to improve drying. Having properly prepared your grains and legumes for storage, you're now ready to package it.

Dry Milk

Nonfat Dry Milk

This is pasteurised skim milk reduced to a powdered concentrate. It can be found in two forms, regular and instant. They are both made from milk in a spray-drying process, but the instant variety has been given further processing to make it more easily soluble in water than regular dry milk. Both types have the same nutrient composition. The regular variety is more compact and requires less storage space than the instantised variety, but it is more difficult to reconstitute.

The most easily found variety is the instant, available in nearly any grocery store. The regular variety has to be sought out from baking and restaurant suppliers and storage food dealers. It takes about 3 tablespoons of instant nonfat dry milk added to 8 ozs of water to make 1 cup of milk you can drink or cook with just like fresh milk, albeit with a considerable flavour difference. Combine the dry milk with water at least several hours before you plan to use it to give it time to dissolve fully and to develop a fresher flavour. Shaking the fluid milk vigorously will incorporate air and will also help to improve flavour. It can also be used to make yogurt, cheese and most any cultured dairy product that does not require a high fat content.

Flavoured Nonfat Dry Milk

This may be found packaged in a variety of forms from a low calorie diet drink (artificially sweetened) to the other end of the scale, as cocoa mix or malted milk. The key ingredient is the dry milk so buy and store these products accordingly.

Dry Whole Milk

This dry milk has a higher fat content and therefore a shorter shelf life than nonfat. Other than that, it can be used in exactly the same way. Dry whole milk is difficult to find, but can sometimes be found where camping and outback supplies are sold.

Dry Buttermilk

Dry buttermilk is for use in recipes calling for buttermilk. Since it has a slightly higher fat content than nonfat dry milk, it generally does not keep as long.

Buying Dry Milk Products

- Be sure the dry milk you are buying has been fortified with vitamins A and D. Almost all of the nonfat dry milks come fortified with these two vitamins. The dry buttermilk does not come this way, at least the SACO brand does not.
- “Extra Grade” on the label indicates the manufacturer has held to higher processing and quality standards and the milk is somewhat lower in fat, moisture and bacterial content, is more soluble, and has fewer scorched particles.
- There are still some manufacturers of dry milk that sell ordinary Grade A product, but they are becoming fewer.
- Try to buy your dried milk in containers of a size that makes sense for the level of consumption in the household. Once it is opened, powdered milk has a short shelf life before undesirable changes in flavour and nutrient content occurs. If you buy large packages and do not use much at one time, consider breaking it down and repackaging into smaller containers at the time of purchase.
- As with any storage food you buy, try to deal only with reputable dealers. It is particularly important to do this with dry milk because of its short shelf life and sensitivity to storage conditions. Check expiration dates, then date and rotate packages.

Storing

Dry milk products are especially sensitive to storage conditions, particularly temperature and light. Vitamins A and D are photo sensitive and will break down rapidly if exposed to light. The area where your dry milk is

stored should be kept as cool as possible. If it is possible to do so, air-conditioning or even refrigeration can greatly extend the nutrient shelf life. If the storage container is transparent or translucent then it should be put into a second container opaque to light or stored in a dark room.

Dry milk will absorb moisture and odors from the air so storage containers should be impervious to both air and moisture. The dryer it can be kept, the better it will keep. Oxygen also speeds decomposition. Powdered milk canned with nitrogen or carbon dioxide to replace air (which contains oxygen) will keep longer than powdered milk exposed to air. Vacuum canning also decreases the available oxygen. If the dry milk purchased was not packaged for long term storage then it should be repackaged right away.

Canned Goods

Liquid Milk

Preserved liquid milk comes in a number of forms, none of which are very similar to each other. The most common forms of these packaged milk are as follows:

Canned Milks

These are commonly called UHT milks (Ultra High Temperature) for the packaging technique used to put them up. They come in the same varieties as fresh liquid milks: whole, 2%, 1% and skim.

Evaporated

This is made from fresh, unpasteurised whole milk. The process removes 60% of the water; the concentrate is heated, homogenised, and in the States vitamin D is

added. It is then canned and heated again to sterilise the contents. It may also have other nutrients and chemical stabilisers added. A mixture of one part water and one part evaporated milk will have about the same nutritional value of an equal amount of fresh milk. There is generally no date or "use by" code on evaporated milk. Health and nutrition food stores often carry canned, evaporated goat's milk, in a similar concentration.

Sweetened Condensed

This milk goes through much less processing than evaporated milk. It starts with pasteurised milk combined with a sugar solution. The water is then extracted until the mixture is less than half its original weight. It is not heated because the high sugar content prevents spoilage. It's very high in calories, too: 8 oz has 980 calories. Although it is often hard to find, the label has a stamped date code which indicates the date by which it should be consumed. Sweetened, condensed milk may thicken and darken as it ages, but it is still edible.

Shelf Life of Canned Milks

Unopened cans of evaporated milk can be stored on a cool, dry shelf for up to six months. Canned milk (UHT) should be stored till the stamped date code on the package (3 - 6 months). Check the date on sweetened, condensed milk for maximum storage.

Corrosion Prevention

Some areas have difficulty storing metal canned goods for long periods of time. This is usually caused by very high humidity or exposure to salt in a marine environment. If this is a problem, it is possible to extend the life of metal cans by coating their outsides. There are at least four methods that can be used to do this:

Paraffin method: Using a double boiler, paraffin is melted and brushed on the clean, unruined cans. Be certain to get a good coat on all seams, particularly the joints. If the can is small enough, it can be dipped directly into the wax. Care must be taken to not cause the labels to separate from the cans. Do not leave in long enough for the can to get warm.

Paste wax method: Combine 2-3 ozs of paste or jelly wax with a quart of mineral spirits. Warm the mixture carefully in its container by immersing it in a larger container of hot water. Do not heat over an open flame! Stir the wax/spirits thoroughly until it is well mixed and dissolved. Paint the cans with a brush in the same manner as above. Place the cans on a wire rack until dry.

Spray silicone: A light coating of ordinary spray silicone may be used to deter rust. Spray lightly, allow to dry, wipe gently with a clean cloth to remove excess silicone.

Clear coating: A clear type of spray or brush on coating such as Rustoleum (tm) may be applied. This is best suited for larger resealable cans, but will keep them protected from corrosion for years.

Sugar, Honey and Other Sweeteners

There are a wide number of sugars to be found for purposes of sweetening foods. Fructose is the primary sugar in fruit and honey; maltose is one of the sugars in malted grains; pimentose are found in olives and sucrose is what we know as granulated or table sugar. Sucrose is a highly refined product made mostly from sugar cane though sugar beets still contribute a fair amount of the world supply as well. Modern table sugar is now so highly refined as to be virtually 100% pure and nearly indestructible if protected from moisture. Powdered sugar

and brown sugar are simple variations on granulated sugar and share its long life.

Liquid sweeteners do not have quite the longevity of dry sugars. Honey, cane syrup, molasses, corn syrup and maple syrup may crystallise or mold during long storage. These syrups are chemically not as simple as table sugar and therefore lose flavour and otherwise break down over a long period of time.

Types of Sugars

Buying granulated sugar and its close cousins is really a very simple matter. Buy a brand you know you can trust and be certain the package is clean, dry and has no insect infestation. There's very little that can go wrong with it.

Granulated sugar

Granulated sugar does not spoil, but if it gets damp it will likely cake up or get lumpy. If it does, it can simply be pulverised again until it regains its granulated texture. Granulated sugar can be found in varying textures, coarser or finer.

Powdered, confectioners or icing

All names refer to the same kind of sugar, that is white granulated sugar very finely ground. For commercial use there is a range of textures from coarse to ultra-fine. For home consumption, what is generally found is either Very Fine (6X) or Ultra-Fine (10X), but this can vary from nation to nation. Not all manufacturers will indicate the grind on the package though. Sugar refiners usually add a small amount of corn starch to prevent caking. Powdered sugar is as inert as granulated sugar, but it is even more hygroscopic and will absorb any moisture present. If it absorbs more than a little it may cake up and

get hard. It's difficult to reclaim hardened powdered sugar, but it can still be used like granulated sugar.

Brown sugar, light/dark

In the United States brown sugar is basically just refined white sugar that has had a bit of molasses or sugar syrup and caramel colouring added to it. Dark brown sugar has more molasses which gives it a stronger flavour, a darker colour and makes it damp. Light brown sugar has less molasses which gives it a milder flavour, a blonder colour and is slightly dryer than the dark variety. For storage purposes you may want to just stock the dark variety. Light brown sugar can be made by combining one fourth to one third white sugar to the remainder dark brown sugar and blend thoroughly.

Both varieties need to be protected from drying out, or they will become very hard and difficult to deal with. Nor do you want to allow them to become damper than what they already are. There are granulated and liquid brown sugars available, but they don't have the same cooking qualities as ordinary brown sugars. They also don't dry out and harden quite so readily either.

Types of Honey

Honey is probably the oldest sweetener known to man. It predates recorded history and has been found in the Egyptian pyramids. It's typically sweeter than granulated sugar by a factor of 25%-40% depending upon the specific flowers from which the bees gather their nectar. This means a smaller amount of honey can give the same amount of sweetening as sugar. The source flowers also dictate the flavour and the colour of the sweetener as well. Honey colour can range from very dark to almost colourless.

As a general rule, the lighter the colour and the more delicate the flavour, the greater the price the honey will bring. As you might expect, since honey is sweeter than table sugar, it also has more calories as well—22 per teaspoon compared to granulated sugar's 16 per teaspoon. There are also trivial amounts of minerals and vitamins in the bee product while white sugar has none. Raw honey may also contain minute quantities of botulinum spores and should not be fed to children under one year of age.

Raw honey is ok for older children and adults. Honey is not a direct substitute for table sugar however, it's use in recipes may call for a bit of alteration to get the recipe to turn out right. Honey comes in a number of forms in the retail market and they all have different storage characteristics:

Whole-comb

This is the bee product straight from the hive. This is the most unprocessed form in which honey comes, being found as large pieces of waxy comb floating in raw honey. The comb itself will contain many unopened honey cells.

Raw

This is unheated honey that has been removed from the comb. It may contain bits of wax, insect parts and other small detritus.

Filtered

This is raw honey that has been warmed slightly to make it more easy to filter out small particles and impurities. Other than being somewhat cleaner than raw honey it is essentially the same. Most of the trace amounts of nutrients remain intact.

Liquid

This is honey that has been heated to higher temperatures to allow for easier filtering and to kill any microorganisms. Usually lighter in colour, this form is milder in flavour, resists crystallisation and generally clearer. It stores the best of the various forms of honey. Much of the trace amounts of vitamins, however, are lost.

Crystallised or spun

This honey has had some of its moisture content removed to make a creamy, spread. It is the most processed form of honey.

Much of the honey sold in supermarkets has been blended from a variety of different honeys and some may have even had other sweeteners added as well. Like anything involving humans, buying honey can be a tricky business. It pays to deal with individuals and brands you know you can trust. Honey grading is a matter of voluntary compliance which means some producers may be lax and sloppy about it. This can be a real nuisance when producers use words like "organic", "raw", "uncooked" and "unfiltered" on their labels, possibly to mislead.

Fortunately, most honey producers are quite honest in their product labelling so if you're not certain of who to deal with, it is worthwhile to ask around to find out who produces a good product. Honey may also contain trace amounts of drugs used in treating various bee ailments, including antibiotics. If this is a concern to you, then it would be wise to investigate with your local honey producer what has been used.

Storage Methods

Honey is much easier to store than to select and buy.

Pure honey won't mold, but may crystallise over time. Exposure to air and moisture can cause colour to darken and flavour to intensify and may speed crystallisation as well. Comb honey doesn't store as well liquid honey so you should not expect it to last as long.

Storage temperature is not as important for honey, but it should be kept from freezing and not exposed to high temperatures if possible. Either extreme can cause crystallisation and heat may cause flavour to strengthen undesirably. Filtered liquid honey will last the longest in storage. Storage containers should be opaque, airtight, moisture- and odor-proof. Like any other stored food, honey should be rotated through the storage cycle and replaced with fresh product.

If crystallisation does occur, honey can be reliquified by placing the container in a larger container of hot water until it has melted. Avoid storing honey near heat sources and if using plastic pails don't keep it near petroleum products (including gasoline engines), chemicals or any other odor-producing products.

Types of Cane Syrups

Molasses and cane syrup

These two sweeteners are not precisely the same thing. Molasses is a by-product of sugar refining and cane syrup is simply cane juice boiled down to a syrup, in much the same way as maple syrup is produced. Non-Southerners (U.S.) may know it better as "unsulphured molasses" even if this is not completely correct. Sulphured molasses is available on the market and very cheap as well, but it's strong flavour is unattractive and generally not desirable.

Sorghum syrup

This is produced in the same manner as cane syrup, but sorghum cane, rather than sugar cane, is used. Sorghum tends to have a thinner, slightly sourer taste than cane syrup.

Treacle

This sweetener comes in varying colours from a rather dark version, similar to, but not quite the same as blackstrap molasses, to paler versions more similar to golden syrup. All these syrups are generally dark with a rich, heavy flavour.

Golden syrup

This syrup seems to be both lighter and paler in colour than any of the above three.

Table syrup

There are many "table syrups" sold in supermarkets, some with flavourings of one sort or another such as maple, various fruits, etc. A close examination of the ingredients list will reveal mixtures of cane syrup, cane sugar syrup or corn syrup along with preservatives, colourings and other additives. They usually have a much less pronounced flavour than molasses, cane syrup, sorghum or the darker treacles. Any syrup containing corn syrup should be stored as corn syrup.

Storing Methods

All of the above syrups, except for those having corn syrup in their makeup, have the same storage characteristics. They can be stored on the shelf for about two years and up to a year after opening. Once they are opened, they are best kept in the refrigerator to retard

mold growth. If mold growth does occur, the syrup should be discarded. The outside of the bottle should be cleaned of drips after each use. Some pure cane and sorghum syrups may crystallise in storage, but this causes no harm and they can be reliquified using the same method as for honey.

Corn Syrup

Corn syrup is a liquid sweetener made by an enzyme reaction with corn starch. Available in both a light and a dark form, the darker variety has a flavour similar to molasses and contains refiners syrup (a byproduct of sugar refining). Both types often contain flavourings and preservatives. They are commonly used in baking and candy making because they do not crystallise when heated.

Corn syrup stores poorly compared to the other common sweeteners and because of this it often has a "best if used by" dating code on the bottle. It should be stored in its original bottle, tightly capped, in a cool, dry place. New unopened bottles keep about six months from the date on the label. After opening, keep the corn syrup four to six months. These syrups are very prone to mold and to fermentation so be on the lookout for bubbling or a mold haze. If these present themselves, throw the syrup out. You should always be certain to wipe off any drips from the bottle after every use.

Maple Syrup

Maple syrup is probably the only sweetener that has developed a cult-like following (OK, cane syrup has its ardent fans too). Produced by boiling down maple sap until it reaches a syrup consistency, it is slightly sweeter than table sugar. Maple syrup is judged by much the

same criteria as honey: Lightness of colour, clarity and taste. Pure maple is generally expensive and most pancake syrups are corn and cane sugar syrups with either natural or artificial flavourings.

New unopened bottles of maple syrup may be kept on a cool, dark, shelf for up to two years. The sweetener may darken and the flavour get stronger, but it is still usable. After the bottle has been opened, it should be refrigerated. It will last about a year. Be careful to look out for mold growth. If mold occurs, discard the syrup. Flavoured pancake syrups should be kept and stored as corn syrups.

Fats and Oils

All oils are fats, but not all fats are oils. They are very similar to each other in their chemical makeup, but what makes one an oil and another a fat is the percentage of hydrogen saturation in the fatty acids of which they are composed. The fats and oils which are available to us for culinary purposes are actually mixtures of differing fatty acids so for practical purposes we'll say saturated fats are solid at room temperature (70 F) and unsaturated fats we call oils are liquid at room temperature. For dietary and nutrition purposes fats are generally classified as saturated, monosaturated and polyunsaturated, but this is just a further refinement of the amount of saturation of the particular compositions of fatty acids in the fats.

There is a problem with storing oils and fats for the long term and that is the fact that they go rancid rather quickly. Rancid fats have been implicated in increased rates of heart disease, atherosclerosis and are carcinogenic (cancer causing) so we want to avoid them if possible. Oxygen is eight times more soluble in fats than in water and it is the oxidation resulting from this exposure that is the primary cause of rancidity.

The more polyunsaturated a fat is, the faster it will go rancid. This may not, at first, be readily apparent because vegetable oils have to become several times more rancid than animal fats before our noses can detect it. An extreme example of rancidity is the linseed oil (flaxseed) that we use as a wood finish and a base for oil paints. In just a matter of hours the oil oxidises into a solid polymer. This is very desirable for wood and paint, very undesirable for food.

Because of this difficulty in storing fats and oils for any long period of time many books and articles on the subject of food storage make only passing mention of them, if they say anything at all. This is unfortunate because fat contains nine calories per gram compared to the four calories contained by either carbohydrates or protein. This makes fat a valuable source of concentrated calories that could be of real importance if faced with a diet consisting largely of unrefined grains and legumes.

For small children, infants and the elderly, they may not be able to consume the volume of food that would be necessary in the course of a day to get all of the calories they would need to avoid weight loss and possible malnutrition. Additionally, fats play an important role in our perception of taste and texture and their absence would make many foods more difficult to prepare and consume. Furthermore, a small amount of dietary fat is necessary for our bodies to properly absorb fat soluble vitamins like A,D,E and K. Long term storage of fats may be problematical, but it is not impossible. There are some general rules you can follow to get the most life out of your stored cooking oils and fats.

1. Exposure to oxygen, light and heat are the greatest factors to rancidity. If you can, refrigerate your stored oil, particularly after it's been opened. If

possible, buy your oils in opaque, airtight containers. If you purchase it in plastic, particularly clear plastic, then transfer it to a gas impermeable glass or metal container that can be sealed airtight. If you have a means of doing so, vacuum sealing the storage container is an excellent idea as it removes most of the air remaining inside, taking much of the oxygen with it. Transparent glass and plastic containers should be stored in the dark, such as in a box. Regardless of the storage container, it should be stored at as cool a temperature as possible and rotated as fast as is practical. Oils and fats with preservatives added by the manufacturer will have a greater shelf life than those without them, provided they are fresh when purchased.

2. Unless they have been specially treated, unopened cooking oils have a shelf life of about a year, depending upon the above conditions. Some speciality oils such as sesame and flax seed have even shorter usable lives. If you don't use a great deal of it, try not to buy your fats in large containers. This way you won't be exposing a large quantity to the air after the you've opened it, to grow old and possibly rancid, before you can use it all up. Once opened, it is an excellent idea to refrigerate cooking fats. If it turns cloudy or solid, the fat is still perfectly usable and will return to its normal liquid, clear state after it has warmed to room temperature. Left at room temperatures, opened bottles of cooking oils can begin to rancid in anywhere from a week to a couple of months, though it may take several more months to reach such a point of rancidity that it can be smelled.
3. Although darker coloured oils have more flavour than paler coloured, the agents that contribute to

that flavour and colour also contribute to faster rancidity. For maximum shelf life buy paler coloured oils.

4. If you have no particular problem with using it, the culinary fat with the most shelf life as it comes from the store is hydrogenated shortening in its unopened metal or metal lined can. The brand most familiar in the U.S. is probably Crisco (tm), but there are many others. Solid shortening is usually composed of partially hydrogenated vegetable oils, but there are some that also contain animal fats. Some brands will also contain anti-oxidant preservatives as well. All other conditions being equal, those with preservatives will have a longer shelf life than those without. It is not possible to give an exact answer, but it is reasonable to expect an unopened metal can of shortening to have a shelf life of eight to ten years if kept reasonably cool, particularly if it has preservatives in it.

Use of Anti-oxidants Preservatives

If obtaining the maximum shelf life in your cooking oils is important to you, it is possible to add anti-oxidant preservatives to the fat after you have purchased it. If used in conjunction with a gas impermeable container, either opaque in colour or stored in a dark place, and cool storage temperatures (70 F or less) then shelf life can be extended to about five years, possibly longer. The anti-oxidant in question is Butylated HydroxyToluene (BHT). It is used in the food industry to slow the development of off-flavours, odors and colour changes caused by oxidation, mostly in foods that are high in fats and oils.

BHT is on the U.S. Food and Drug Administration's Generally Recognised As Safe (GRAS) list as a common

preservative. The FDA limits the use of BHT to 0.02% or 200 parts per million (ppm) of the oil or fat content of a food product. BHT is available over the counter in the retail trade, but you have to know where to look for it.

To get the best results you will need the freshest oil you can find. Purchasing it from a large, busy supermarket will probably suffice. You'll also need containers that are gas impermeable such as glass jars, or metal cans. There may be plastic containers made of thick High Density PolyEthylene (HDPE) that will also serve. Make sure your containers are clean, dry and dust-free.

Each 250 milligram capsule is sufficient to treat 47 fluid ounces of cooking oil. If you have an accurate means of weighing this works out to be 5.3 mg of BHT crystals to every 1 fl oz of oil. If you're using a scale calibrated in grains, such as a reloading powder scale, you may use the following table.

<i>BHT in grains</i>	<i>Oil</i>	<i>BHT in milligrams</i>
0.1	1 fl oz	5.3
0.7	8 fl oz (1 cup)	42.4
1.3	16 fl oz (1 pint)	84.8
2.6	32 fl oz (1 quart)	169.6
5.2	64 fl oz (1/2 gal)	339.2
10.3	128 fl oz (1 gal)	678.4

Remove the BHT crystals from their gelatin capsules and weigh, if you're going to. Once you have the appropriate amount, add the crystals to a pint or so of the oil, shaking vigorously. It may take several hours for the preservative to dissolve completely. Bringing the oil up to a warm, not hot, temperature will speed the process. Once completely dissolved, pour the anti-oxidant laden oil into the rest of

the oil and mix thoroughly. Once mixed, the oil can then be poured into its storage containers leaving approximately 1/2 inch of headspace.

If you have a vacuum sealer the jars or cans may be vacuum sealed to remove most of the oxygen from the container, otherwise just seal the lid. Store in a cool place and if using transparent jars, be certain to put them in a larger container such as a box to keep the contents in the dark. Don't forget to label and date the jars.

Cooking Staples

Baking Powder

This powder is a combination of an acid, an alkali, and a starch to keep the other ingredients stable and dry. The powder reacts with liquid by foaming and the resulting bubbles can aerate and raise dough. Almost all baking powder now on the market is double acting, meaning it has one acid that bubbles at room temperature and another acid which only reacts at oven temperatures. Unless a recipe specifies otherwise, this is the type to use. Don't expose baking powder to steam, humid air, wet spoons, or any other moisture.

Store in a tightly lidded container for no more than a year. Even bone dry baking powder eventually loses its potency. To test its strength, measure 1 tsp powder into 1/3 cup hot water. The mixture should fizz and bubble furiously. If it doesn't, throw the baking powder out. For those folks concerned with aluminum in the diet, the Rumford brand has none in it and there may be others.

Baking Soda

This gritty powder is sodium bicarbonate also called sodium acid bicarbonate (NaHCO_3), a mild alkali. It is

used in baking to leaven bread and does so in the same manner as baking powder. When combined with an acid ingredient, the bicarbonate reacts to give off carbon dioxide bubbles which causes the baked good to rise. If kept well sealed in an air- and moisture-proof container its storage life is indefinite. If kept in the cardboard box it usually comes in, it will keep for about eighteen months. Do keep in mind that baking soda is a wonderful odor absorber. If you don't want your baked goods tasting of whatever smells it absorbed then keeping it in an airtight container is an excellent idea.

Herbs and Spices

It is difficult to give exact instructions on how best to store culinary herbs and spices because there are dozens of different seeds, leaves, roots, barks, etc., we call an herb or a spice. There are, however, some general rules to be followed to best preserve their flavors. All spices, particularly dried, are especially sensitive to heat, air and light. Room temperature is fine for keeping them and refrigeration or freezing is even better, but they should be kept away from heat sources. It is common for the household spice cabinet or shelf to be located over the stove, but this is really a very poor place.

Dark opaque glass is best for storage, but failing that, keeping a tightly sealed glass container in a dark place is next best. The cellophane packets some products come in just won't do for storage. Tightly sealed metal containers will work as well. Even dense plastic will do, but glass is best. Where possible, buy spices whole. Whole nutmegs will keep their flavour far longer than ground nutmeg, the same for other seeds and roots. You'll have to use a grater, grinder or whatever, but the difference in flavour will be worth it.

If you buy spices in bulk containers (which is certainly cheaper) consider transferring some into smaller containers and keeping the larger one tightly sealed in a cool, dark place. This will prevent unwanted light and air from continually getting in and playing havoc. Included in the suppliers addresses are listings for several spice and herb companies.

Salt

Storage life for salt is indefinite. So long as you do not let it get contaminated with dirt or whatever, it will never go bad. Over time, iodised salt may turn yellow, but this is harmless and may still be used. Salt is rather hygroscopic and will adsorb moisture from the air if not sealed in an air-tight container. If it does adsorb moisture and cakes up, it can be dried in the oven and then broken up with no harm done.

All salt, however, is not the same. Salt comes in a number of different varieties, each with its own purpose. Very little of the salt produced in the U.S. is intended for use in food. The rest of it, about 98%, has other uses. Therefore, it is important to be certain the salt you have is intended for human consumption. Once you are satisfied it is, you should then determine its appropriateness for the tasks to which you might want to set it to. Below is a partial list of some of the available salts.

Table Salt

This is by far the most widely known type of salt. It comes in two varieties; iodised and non-iodised. There is an ingredient added to it to absorb moisture so it will stay free flowing in damp weather. This non-caking agent does not dissolve in water and can cause cloudiness in whatever solution it is used if sufficiently large quantities

are used. In canning it won't cause a problem since there is very little per jar. For pickling, though, it would be noticeable. If you are storing salt for this purpose, you should be sure to choose plain pickling salt, or other food grade pure salt such as kosher salt. In the iodised varieties, the iodine can cause discoloration or darkening of pickled foods so be certain not to use it for that purpose.

Canning Salt

This is pure salt and nothing, but salt. It can usually be found in the canning supplies section of most stores. This is the salt to be preferred for most food preservation or storage uses. It is generally about the same grain size as table salt.

Kosher Salt

This salt is not really, in itself, kosher, but is used in "kashering" meat to make the flesh kosher for eating. This involves first soaking the meat then rubbing it with the salt to draw out the blood which is not-kosher and is subsequently washed off along with the salt. The remaining meat is then kosher. What makes it of interest for food storage and preservation is that it is generally pure salt suitable for canning, pickling and meat curing.

It is of a larger grain size than table or canning salt, and usually rolled to make the grains flaked for easier dissolving. Frequently it is slightly cheaper than canning salt and usually easier to find in urban/suburban areas. Whether flaked or in its unaltered crystal form, kosher salt takes up more volume for an equivalent amount of mass than does canning salt. If it is important to get a very precise amount of salt in your pickling or curing recipe you may want to weigh the salt to get the correct amount.

Sea Salt

This type of salt comes in about as many different varieties as coffee and from about as many different places around the world. The “gourmet” versions can be rather expensive. In general, the types sold in grocery stores, natural food markets and gourmet shops have been purified enough to use in food. It’s not suitable for food preservation, though, because the mineral content it contains (other than the sodium chloride) may cause discoloration of the food.

Rock or Ice Cream Salt

This type of salt comes in large chunky crystals and is intended primarily for use in home ice cream churns to lower the temperature of the ice filled water in which the churn sits. It’s also sometimes used in icing down beer kegs or watermelons.

Solar Salt

This is also sometimes confusingly called “sea salt”. It is not, however, the same thing as the sea salt found in food stores. Most importantly, it is *not* food grade. It’s main purpose is for use in water softeners. The reason it is called “solar” and sometimes “sea salt” is that it is produced by evaporation of sea water in large ponds in various arid areas of the world. This salt type is not purified and still contains the desiccated remains of whatever aquatic life might have been trapped in it. Those organic remains might react with the proteins in the foods you are attempting to preserve and cause it to spoil.

Halite

For those of us fortunate enough to live in areas warm

enough not need it, halite is the salt that is used on roads to melt snow and ice. It, too, is not food grade and should not be used in food preservation. This form of salt is also frequently called rock salt, like the rock salt above, but neither are suitable for food use.

Salt Substitutes

These are various other kinds of metal salts such as potassium chloride used to substitute for the ordinary sodium chloride salt we are familiar with. They have their uses, but should not be used in foods undergoing a heated preservation processing, as they can cause the product to taste bad. Even the heat from normal cooking is sometimes sufficient to cause this.

Vinegar

There is vinegar and then there is vinegar and it is not all alike. The active ingredient in all vinegars is acetic acid, but what the sour stuff is made from can vary widely. The most common vinegar is the white distilled variety which is actually just diluted distilled acetic acid and not true vinegar at all. It keeps pretty much indefinitely if tightly sealed in a plastic or glass bottle with a plastic cap. The enamel coated metal caps always seem to get eaten by the acid over time. It is usually about 5-6% acetic acid and for pickling it is the type most often called for.

The next most common variety is apple cider vinegar. There are two kinds of this type. A "cider flavoured" distilled acetic acid type and a true cider vinegar fermented from hard cider. Either will store indefinitely at room temperature until a sediment begins to appear on the bottom. Stored vinegar will sometimes develop a cloudy substance. This is called a "mother of vinegar" and it is harmless. As long as the liquid does not begin to

smell foul it can be filtered out through cheesecloth or a coffee filter and rebottled in a clean container.

The mother can even be used to make more vinegar. If it begins to smell bad, however, it's gone over and should be tossed out. The more exotic wine vinegars, balsalmic and other types all can be stored like cider vinegar. Age and exposure to light and air, however, eventually begin to take their toll on their delicate flavors. Tightly capped in a cool, dark cabinet or refrigerator is best for their storage.

Yeast

Yeast is just not a product you can stow away and forget about until you need it next year. It is, after all, a living organism and if it's not alive at the time you need it, you won't get any use out of it. This ancient leavening, brewing, fermenting agent is a single celled microscopic fungus. When we incorporate it into our bread dough, beer wort or fruit juice it begins to reproduce madly and produce several by-products.

If you're baking, the by-product you want is carbon dioxide which is trapped by the dough and subsequently causes it to rise. In brewing or vintning what is wanted is the ethyl alcohol and, if the drink is to be carbonated, the carbon dioxide. Almost all yeasts used for these purposes are in the same genus (*Saccharomyces* or "sugar fungi"), but several different species have evolved and some are more suitable for a particular task than others. It's entirely possible to use grocery store bread yeast to brew beer or ferment wine, but the results may leave a great deal to be desired.

Compressed yeast is only partly dried (about 70% moisture) and requires refrigeration and keeps even better in the deep freeze. If kept in an air- and moisture-

tight container to prevent it from desiccating this type of yeast will keep for a year in the freezer (0 degs F or less, but only about two weeks (maybe a bit more) in the refrigerator. Unless your kitchen is rather chilly it will not keep on the shelf. It should not have a mottled colour or a sour odor. Dried yeast has only an 8% moisture content and comes packed in foil envelopes. The smaller single use packets are not generally vacuum packed, but the larger commercial sized "bricks" of about a pound or two each generally are. They can last for months on the shelf, up till the expiration date which should be clearly stamped on the package.

If packaged in the same manner as recommended for compressed yeast above and kept in the refrigerator or freezer it can last for several years. The larger packs of yeast should be transferred to an air and moisture tight container after opening. Either type of yeast can be tested for 'viability by "proofing" it. This is nothing more than mixing a small amount of the yeast with an equal amount of sugar in warm water (105-115 deg F for dried; 95 deg F for fresh). Within about five minutes active yeast will become bubbly and begin to expand (at normal room temperature). Yeast which only slowly becomes active can still be used, but you will have to use more of it. If it shows no activity at all, it's dead and should be thrown out.

6

Food Preservation Methods

Food preservation is the process of treating and handling food in such a way as to stop or greatly slow down spoilage to prevent foodborne illness while maintaining nutritional value, texture and flavour.

Heat Sterilisation

Sterilisation (or sterilisation) is the elimination of all transmissible agents (such as bacteria, prions and viruses) from a surface, a piece of equipment, food or biological culture medium. This is different from disinfection, where only organisms that can cause disease are removed by a disinfectant.

Heat sterilisation is known to have been in used in Ancient Rome, but it mostly disappeared throughout the Middle Ages where sanitation was not usually a concern. The preferred principle for sterilisation is through heat. There are also chemical methods of sterilisation.

Autoclaves

A widely-used method for heat sterilisation is the autoclave. Autoclaves commonly use steam heated to 121°C (250°F), at 103 kPa (15 psi) above atmospheric pressure, for 15 minutes. The steam and pressure transfer

sufficient heat into organisms to kill them. Proper autoclave treatment will inactivate all fungi, bacteria, viruses and also bacterial spores, which can be quite resistant. It will not necessarily eliminate all prions.

To ensure the autoclaving process was able to cause sterilisation, most autoclaves have meters and charts that record or display pertinent information such as temperature and pressure as a function of times. Indicator tape is often taped onto packages of products to be autoclaved. The tape contains a chemical that will change colour when the appropriate conditions have been met. Some types of packaging have built-in indicators on them.

Biological indicators ("bioindicators") can also be used to independently confirm autoclave performance. Several simple bioindicator devices are commercially available based on microbial spores. Most contain pure strains of the heat resistant microbe *Geobacillus stearothermophilus* which are among the toughest organisms an autoclave will have to destroy (such as the Attests). Several of these devices have a self-contained growth medium (with or separate to the spores) and a growth indicator. After a run in an autoclave, the internal glass in the Attest vial is shattered, allowing the spores into a differential liquid medium.

If the autoclave destroyed the spores, the medium will remain a blue colour. If autoclaving was unsuccessful the *G. stearothermophilus* will metabolise, causing a yellow colour change after two days of incubation at 56°C (132°F). For effective autoclaving, the steam needs to be able to penetrate everywhere. For this reason, an autoclave must not be overcrowded, and the lids of bottles and containers must be ajar. Indicators should be placed in the most difficult place sterilisation is wanted;

for instance, if you are sterilising the contents of universals (a type of small glass jar), the Attest vial should be placed in a universal, to ensure that steam actually penetrates these areas.

For autoclaving, as for all disinfection or sterilisation methods, the cleaning off of any biological material is also critical. Biological matter or any grime may shield organisms from the property intended to kill them, whether it physical or chemical. Cleaning can also remove a large number of organisms at once. Proper cleaning can be achieved by physical scrubbing to remove dirt; this should be done with detergent and warm water to get the best results. Where it is not feasible, ultrasound or pulsed air can be used to remove debris.

Food utensils

Dishwashers often only use hot tap water or heat the water to between 49 and 60°C (120 and 140°F), and thus provide temperatures that could promote bacterial growth. That is to say, they do not effectively sterilise utensils. Some dishwashers do actually heat water up to 74°C (165°F) or higher; those often are specifically described as having sterilisation modes of some sort, but this is not a substitute for autoclaving.

Note that dishwashers remove food traces from the utensils by a combination of mechanical action (the action of water hitting the plates and cutlery) and the action of detergents and enzymes on fats and proteins. This removal of food particles thus removes one of the factors required for bacterial growth (food), and explains why items with cracks and crevices should either be washed by hand or disposed of: if the water cannot get to the area needing cleaning, the warm, moist, dark conditions in the dishwasher can actually promote bacterial growth.

Other methods

Other heat methods include using dry heat, boiling, flaming and incineration.

Flaming is done to loops and straight-wires in microbiology labs. Leaving the loop in a Bunsen burner flame until it glows red ensures that any infectious agent gets inactivated. This is commonly used for small metal or glass objects, but not for large objects.

Incineration will also burn any organism to ash. It is used to sanitise medical and other biohazardous waste before its ash goes to the tip. Boiling in water for 15 minutes is unsuitable for sterilisation. It is a simple and familiar enough process for anyone to do, though is hazardous and cumbersome. Boiling will kill bacteria and viruses, but it is ineffective against many bacterial spores and prions.

Dry heat can be used to sterilise items, but as the heat takes much longer to be transferred to the organism, both the time and the temperature must be increased. The standard setting for a hot air oven is at least two hours at 160°C (320°F). A rapid method heats air to 190°C (374°F) for 6–12 hours. Dry heat has the advantage that it can be used on powders and other heat-stable items that are adversely affected by steam (for instance, it does not cause rusting of steel objects).

For prion elimination, various recommendations state 121–132°C (270°F) for 60 minutes or 134°C (273°F) for at least 18 minutes. The prion that causes the disease scrapie (strain 263K) is inactivated relatively quickly by such sterilisation procedures; however, other strains of scrapie, as well as strains of CJD and BSE have shown much more resistance. Using mice as test animals, one experiment showed that heating BSE positive brain tissue at 134-

138°C (273-280°F) for 18 minutes resulted in only a 2.5 log decrease in prion infectivity. (The initial BSE concentration in the tissue was relatively low). To have a significant margin of safety, cleaning should reduce infectivity 4 logs, and the sterilisation method should reduce it a further 5 logs.

In the home, sterilisation is carried out using a pressure cooker. Many of you probably have seen your grandmother, or perhaps your mother, using this container to sterilise home-canned food. The pressure cooker works as follows:

- A pint or so of water is placed in the bottom of the pressure cooker.
- The food to be sterilised is placed in the container with the lids loose.
- The top is placed on tightly and the water is brought to a boil until all the air is vented through the outlet port.
- Then a weight is placed on the outlet port. This weight is adjusted so that steam will only escape once the pressure has reached 15 pounds per square inch. At this pressure the temperature will reach 123°C at sea level.
- Once this temperature is reached and steam begins to bleed from the port, heating is continued for a period of time necessary to bring all the food in the containers to 123°C for 15 to 20 min.
- The heat is turned off and the contents are allowed to cool.
- Finally, the pressure cooker cover is removed, and the jar lids tightened immediately to prevent contamination from entering.

In the microbiology laboratory and commercial canning companies sterilisation is achieved by using large containers that operate exactly the same as the home pressure cooker. The laboratory instrument is called an autoclave. In commercial canning processes the sterilisation containers may be as large as rooms and the food is often wheeled in on large carts.

Cooling and Freezing

Except for Eskimos and other inhabitants of the far north, cooling has only emerged as a common means of preserving food since the mid 1800s when the ice-making machine was discovered. Prior to that time it was common in northern climes for people to cut large blocks of ice from local lakes and to store them in insulated warehouses for use during the summer months to cool their beer and other food items.

Cooling as a food preservative is utilised at two levels, 7 to 4°C and -20°C or lower. The higher temperature is commonly used in home refrigerators. At this temperature, the growth of microbes is slowed down but not stopped. Indeed, some microbes grow optimally at these temperatures. The failure to prevent spoilage at this higher temperature is attested to by anyone who has attempted to use milk older than two weeks in a refrigerator or who has left fruits and vegetables in a 'fridge' for extended periods.

At the lower temperature the food is frozen. As microbes are unable to grow in frozen material, freezing is one of the most successful means of preserving food with minimal change in flavour or loss of nutritional value. The major draw back to the use of cooling is that (a) it is expensive and (b) it also preserves many pathogens that happen to be present in the food when it

was cooled. As a matter-of-fact the storage of living material at temperatures of -70°C or lower is the best way of maintaining cells in a state from which they can be subsequently cultured. Such material as sperm, ova, embryos (human and other forms of life), all types of microbes and tissue cells can be frozen and stored for years with little loss of viability providing the procedure is carried out properly.

Drying

Drying as means of preserving food may very well be the oldest method of preservation known to man. Almost certainly it was an accidental discovery made by our primitive ancestors living on the hot plains of Africa. Most likely, our ancestors frequently came across carrion (a sort of road kill) that had dried in the arid conditions. Being hungry, they ripped off the dried meat and chowed down. It didn't take them long to recognise that it wasn't spoiled, that it was light and that it stayed unspoiled as long as it remained dry.

Some budding hairy-Einstein soon realised that fresh meat could be dried by placing it in the hot sun and the human race was off to the races, so to speak. Drying is employed today as a common means of food preservation by all peoples living in warmer climates. Generally the food, such as fresh meat, is cut into small strips and placed on rocks exposed to the sun, or hung over sticks by a campfire. The pieces must be small so that the food dries fast enough to prevent spoilage.

In the case of meat, one trick is to hang it high enough so the flies can't get to it and lay their eggs in it. As the water evaporates and the food dries, the Osmotic Pressure (the result of hydrophilic molecules binding water molecules) increases to a point where microbes are

unable to compete with the water-binding material in the food for the remaining water. Since microbes are unable to grow without free (available) water, the food is safe from spoilage, even though it may retain significant bound-water. In some cases (beef jerky) the food is salted prior to drying. The salt is inhibitory to many microbes and contributes to the high osmotic pressure that prevents microbial growth.

Salts and Other Chemicals

Salt or Sodium Chloride: The use of salt as a food preservative is probably as old as drying, if not older. All mammals need salt and they will travel long distances to obtain it. Our human ancestors certainly visited the ocean or salty lakes to collect the salt that had dried on the shore. Occasionally animals or fish must have died in pools of salty water and then dried in the sun leaving their desiccated carcasses impregnated with salt. Again our ancestors were unlikely to turn down a potential meal and they must have quickly recognised that the salted food was unspoiled and remained so as long as it was impregnated with salt. The salted food served a dual role as a source of nutrition and of sodium chloride, and as it dried it was easier to transport. Before canning, salted meat was the staple food on ships that travelled any significant distances away from land (hence the term "ol salt").

Nitrate (NO_3) (Saltpeter): Nitrate and nitrite salts are used in many foods today as both a preservative and to prevent meat from browning. The bacterium *Clostridium botulinum* is an obligate anaerobe in that the presence of even a tiny amount of free oxygen prevents its growth. Yet, *C. botulinum* readily grows in prepared meats like sausage. Nitrate and nitrite are Oxidising agents that are

chemically similar to oxygen. As such they, like free-oxygen, inhibit the growth of *C. botulinum* in foods.

In addition, they prevent certain substances in meat from becoming reduced, which causes them to turn the meat brown, suggesting that it may be poor quality. In recent years scientists have discovered a link between nitrate/nitrite and the formation of carcinogens. As a consequence of this the FDA has required the removal where possible of these chemicals from foods or the lowering of their concentration to the minimal level. The use of nitrate/nitrite poses a classical cost/benefit conflict.

Sulphite (SO_2) and vitamin C: Most of you have observed the "Browning" of fruits and vegetables; the apple, peach or banana you eat turns brown before your very eyes, even as you chow it down. Generally, people feel that "brown" food items are spoiled or at least of lower quality. The browning results from the actions of enzymes in the fruits and vegetables that rapidly react with oxygen to produce brown-coloured chemicals that protect the damaged food from microbes; i.e., the brown chemical is inhibitory to many microbes.

Sulphite is a powerful "Reducing" chemical that Vlocks the Browning Response, and it is inexpensive, & effective in tiny amounts. Therefore it is common to rinse fruits and vegetables in restaurants in solutions containing Sulphite. This insures that items that were prepared several hours before will remain "fresh-looking" all day long on the customer's plates. At the concentrations used, sulphite is not toxic, but a small percentage of people are highly allergic to sulphite and an exposure to even a tiny quantity of it on lettuce etc. may be sufficient to induce a violent allergy attack. This is why restaurants often have signs telling their customers that they are using sulphite on their foods.

Another powerful reducing agent that serves the same purpose is vitamin C (ascorbic acid). This vitamin also is inexpensive, is effective in small amounts, plus it is beneficial to those who ingest it. However, because it is more expensive than sulphite and it tends to decay faster, it is not universally used.

Organic Acids: As you recall, all microbes require an optimum pH or acidity in their environment to grow. If there is too much acid or base, a microbe will not grow. As the by-products of many microbial fermentations include the production of chemicals like Acetic acid (vinegar), Lactic Acid, and Propionic Acid it is not too surprising to find that humans, and other life, can actually use these substances as nutrients. However, when they are added to foods in sufficient quantities to lower the pH below that which will support the growth of most food-spoilage microbes, they can serve as natural food preservatives.

Again, our ancestors recognised that "Spoiled" foods such as milk and certain vegetables, retained their nutrition upon becoming acidic and remained eatable (preserved) for long periods. Thus was born choice food items like yogurt, sauerkraut, pickles, cheese and buttermilk. Artificial acids, like benzoic acid, inhibit the growth of some molds, thus it is added to breads and other bakery products that require long shelf life. In many foods, like the sauerkraut you made in lab, salt is combined with acids to preserve food.

Antibiotics: Most common antibiotics are inexpensive, stable, safe and effective in small quantities. With their ability to kill or inhibit many microbes, antibiotics might seem the perfect food preservative. However, all is not what it seems. Using antibiotics for food preservation is like using 100 dollar bills for toilet paper; it gets the job

done but it is not the best use for that item. The use of antibiotics in preserving food and in animal feeds has been demonstrated to increase the spread of antibiotic resistance between pathogens. Although some action has been taken to limit the use of antibiotics for these purposes, it is still done in many places.

Radiation: Atomic radiation is becoming widely used in the preservation of food, although its use remains controversial and frightening to many people. In 1997 the FDA approved radiation as a means of preserving meats. Many of the prepared meals available on the supermarket shelves at room temperature have been sterilised by radiation. Atomic radiation is lethal to all life when used in high doses. To sterilise food by this technique, the food is placed in a protected room and exposed to a high dose, usually of gamma radiation, from radioactive wastes refined from atomic power plants. A dosage that had been determined to be lethal to all microbes, including bacterial spores, is used.

Current studies indicate that increased use of irradiation to destroy contaminating microbes would slightly increase the cost, but it is suggested that the increase in cost would be offset by the reduced loss of stored foods. Use of radiation to eliminate *Salmonella enteritidis* contamination from eggs is under consideration.

Sugar

Sugar is used to preserve fruits, either in syrup with fruit such as apples, pears, peaches, apricots, plums or in crystallised form where the preserved material is cooked in sugar to the point of crystallisation and the resultant product is then stored dry. This method is used for the skins of citrus fruit (candied peel), angelica and ginger. A

modification of this process produces glacé fruit such as glacé cherries where the fruit is preserved in sugar but is then extracted from the syrup and sold, the preservation being maintained by the sugar content of the fruit and the superficial coating of syrup. The use of sugar is often combined with alcohol for preservation of luxury products such as fruit in brandy or other spirits.

Pickling

Pickling is a method of preserving food by placing it or cooking it in a substance that inhibits or kills bacteria and other microorganisms. This material must also be fit for human consumption. Typical pickling agents include brine (high in salt), vinegar, ethanol, and vegetable oil, especially olive oil but also many other oils. Most pickling processes also involve heating or boiling so that the food being preserved becomes saturated with the pickling agent.

Frequently pickled items include vegetables such as cabbage (to make sauerkraut and curtido), peppers, and some animal products such as corned beef and eggs. A less-common form of pickling uses sodium hydroxide (lye) to make the food too alkaline for bacterial growth. Lye will saponify fats in the food, which will change its flavour and texture.

Smoking

Smoking is another ancient means of preserving food. Smoking was probably a serendipitous side effect of the discovery of drying food by the campfire. Our ancestors must have frequently stumbled on the partly cooked remains of animals killed in fires and they certainly tore off the smoked and dried pieces of flesh and ate them. They may have realised then, or more likely, after they

had tamed fire, that chunks of food, left in the smoke of the fire while they were off hunting, raiding the nearby tribe or otherwise entertaining themselves, dried out and remained eatable for long periods. Plus the food absorbed pleasing flavours.

When foods are smoked they absorb various chemicals from the smoke including aldehydes and acids. The former is lethal to many microbes and the latter, lowers the pH of the meat. There is danger lurking in this process. Aldehydes are carcinogenic and people who eat a heavy diet of smoked foods suffer disproportionately from cancer of the mouth, stomach and esophagus. This is another case of the "dangers of secondhand smoke".

Food Poisoning and Food Borne Diseases

"Food poisoning" is a general name given to illnesses contracted by consuming contaminated food or water. The microorganisms responsible for illness are bacteria, viruses and fungi, commonly called "germs" or "bugs". But illness can also be caused by chemical contaminants (such as heavy metals), toxins produced by the growth of some microorganisms (eg. Staphylococci bacteria) and by a variety of organic substances that may be present naturally in foods (such as certain mushrooms and some seafood).

Generally food poisoning results from contamination of food and the subsequent growth of food poisoning microorganisms. Food poisoning outbreaks are often recognised by the sudden onset of illness within a short period of time among many individuals who have eaten or drunk one or more foods in common. Single cases are difficult to identify unless, as in Botulism for example, there are distinct symptoms. Food poisoning may be one of the most common causes of acute illness; yet cases and outbreaks are generally under-recognised and under-reported.

Reasons for Food Poisoning

1. Inadequate cooling/refrigeration, food left at room temperature.
2. Too long between preparation and consumption.
3. Inadequate reheating.
4. Inadequate cooking.
5. Cross-contamination from raw to high risk/ready to eat foods.
6. Infected food handlers.
7. Inadequate hot holding temperatures.
8. Inadequate hand washing.
9. Contaminated raw foods and ingredients.
10. Improper cleaning of equipment and utensils.

Prevention from Food Poisoning

In most cases of food poisoning a chain of events takes place, and if we are to reduce the incidence of illness, this chain must be broken.

Food Poisoning Chain

There are three main ways of breaking the food poisoning chain:

- Protecting food from contamination.
- Preventing any bacteria present in the food from multiplying.
- Destroying those bacteria that are present in the food.

Protecting food from contamination by:

- Inspecting all food and washing fruit and vegetables before preparation.
- Separating raw and high risk/ready to eat foods at all stages of preparation, storage, display and distribution.
- The same equipment, utensils and working surfaces must not be used to handle raw and high risk/ready to eat foods.
- Only handling food when unavoidable. Gloves, tongs and other utensils, plates and trays should be used in preference to hands, (but must be washed or changed frequently).
- Keeping food covered as much as possible.
- Preventing insects, animals and birds from entering food rooms.
- Not using unsuitable, defective, or dirty equipment.
- Using good personal hygiene practices – always.
- Not coughing or sneezing over or around food.
- Not handling the food contact surfaces of crockery, cutlery or utensils.
- All food handlers wearing suitable protective clothing.
- Using the correct cleaning procedures.
- Promptly removing unfit or waste food and refuse from food areas.

Preventing any bacteria within food from multiplying by:

- Keeping high risk foods at temperatures that inhibit the growth of bacteria (ie. out of the danger zone). Food should be kept below 4°C in a refrigerated unit, or above 70°C in a suitable warming unit.

- Ensuring that during preparation, food is in the danger zone for as short a time as possible. High risk foods must not be left sitting out at room temperature.
- Using suitable preservatives such as salt and sugar.
- Using various packing methods like gas flushing or vacuum packing.
- Not allowing dried foods to absorb moisture.

Destroying those Bacteria within food by:

- Adequately cooking food, ensuring that a minimum internal cooking temperature of 80°C is reached.
- Heat processing such as pasteurisation, sterilisation or canning.

A combination of a suitable temperature and sufficient time is always required to destroy bacteria. The time and temperature required will depend on the particular organism, (eg. spores of *Clostridium perfringens* are much more heat resistant than *Salmonella* bacteria).

Personal Hygiene

Good personal hygiene reduces the chance of contamination of food.

- Hands must be washed before and after handling food.
- If unwell, do not handle food until cleared by a doctor.
- The hair, nose and mouth must not be touched during food preparation.
- Suitable light coloured protective clothing should be worn.

- Cuts and abrasions should be covered with waterproof bandages and if on the hands suitable gloves worn.
- Rings and other jewellery should not be worn as they can harbour dirt and bacteria and could themselves fall into the food being prepared.

Food Spoilage

Food decays or goes off, due to the microorganisms that always exist in food;- they are not necessarily the bacteria that cause food poisoning. The signs that food is spoiling are:

- Odour-“off odours” are smells (sometimes like rotten eggs) that are produced when bacteria break down the protein in food, (usually fatty foods). This process is called putrefaction.
- Taints due to flavour change may also occur.
- *Sliminess* – Food becomes slimy as the bacterial population grows.
- Moulds may also form slimy whiskers.
- *Discolouration* – Foods can become discoloured by microbial growth.
- Some moulds have coloured spores that give the food a distinctive colour, for example, black pin mould on bread, or blue and green mould on citrus fruit and cheese.
- *Souring* – Foods go sour when certain bacteria produce acids. A common example is when milk sours from the production of lactic acid.
- *Gas* – Bacteria and yeasts often produce gaseous by-products that can affect food. You may have

noticed meat becoming spongy, or packages and cans swelling or having a popping or fizzing sound on opening.

Microorganisms

Microorganisms are often called bugs. This is a little too simple however and food handlers should know a little more about them. They differ from one another in appearance and activity, and looking at those found in food as a whole we find that provided suitable nutrients are available growth occurs:

- At temperatures between -7 to around 70°C.
- Over a pH range from 0 to 11.
- In the presence or absence of oxygen.
- At water activities above about 0.6.

Spoilage of any particular food will be by those organisms most suited to the conditions in and around that food. The three main groups of concern are:

- Bacteria
- Viruses
- Fungi (yeasts / moulds)

Bacteria

Bacteria are microscopic organisms that are found everywhere—in air, soil, water, plants, animals and the human body. You can't see, taste or smell most bacteria. If the environmental conditions are favourable, just about any material will support the growth of some bacteria. Most bacteria are harmless and some are helpful, like those that change milk into cheese or yoghurt. But others cause food spoilage and some known as pathogens are harmful and can cause illness and sometimes death.

The number of bacteria present in food may be used to determine whether or not the food has been handled correctly. The diseases that are spread by bacteria that enter the body in food, can multiply at an amazing rate when they are provided with warmth and moisture, (especially at room temperature). Our food can become an ideal home for them.

Clean food can be contaminated by bacteria from four main sources:

- The people present in the workplace and their clothing.
- Other food that is already contaminated.
- Dirty kitchen or work premises and equipment.
- Insects and vermin.

Sometimes, harmful bacteria pass directly from the source to high risk food, but usually they rely on other things to transfer them to food. These things are called Vehicles. Indirect contamination using an intermediate vehicle is the most common, eg.- the movement of bacteria from the intestine of a food handler to food via their hands, after using the toilet.

Where contamination is passed from raw food to high risk food via for example, a cutting board, this is known as Cross Contamination. The path that bacteria use to move from the source to the food, is known as the Route.

Viruses

Viruses are organisms much smaller than bacteria. In their pre-infective stage they are just like a chemical with none of the requirements for life, but once in a living cell they take over and begin to multiply. They can grow only in living tissue, but can be carried in food from one person to another.

Fungi

Yeasts

Yeasts are single cell organisms much larger than bacteria and can be found in the soil, on plants and on the skin and body of man. They multiply by forming offspring as buds which grow and then detach themselves.

Some can produce disease, some cause skin infections in man and others cause diseases in plants. Some yeasts spoil food, but beneficial uses are in the making of beer, wine and bread.

Moulds

Moulds grow as single cell filaments that can branch together making a strongly knit structure like a mat, that can often be seen with the naked eye. Usually they look fluffy, being a familiar sight on foods like jam, cheese and bread. They multiply by producing clusters of dry spores which are blown by the air like seeds. Many moulds spoil food and a few can cause disease in plants and man, but beneficial uses are in the ripening of cheeses and production of antibiotics.

Growth of Microorganisms

There are certain environmental conditions that must be met for microorganisms to grow and multiply and when these conditions exist they can very quickly increase in number. These conditions are:

- Time
- Food
- Temperature
- pH

- Water
- Oxygen

Anything less than optimum conditions will lead to a slowing down or a stopping of growth and then possibly their death.

Time: Time is needed for the organism to grow and reach maturity. In most cases we try to prevent an organism from maturing by making its environment unsuitable for growth.

Food: All organisms need food for growth and energy.

Temperature: Each microorganism has an optimum temperature where it grows most rapidly and a maximum and minimum temperature at which it will grow. Outside this range it will grow very slowly, or not at all.

pH: The numbers on the pH scale, as shown in the following diagram, indicate the acidity or alkalinity of a fluid. Microorganisms can grow and multiply only within a certain pH range.

Most prefer to live in a neutral environment around pH 7. A small group of microorganisms prefer an acid environment and do not grow in the neutral range. Low pH generally inhibits microbial growth. Yeasts and moulds are the most capable of growth at low pH. Other acid-producing bacteria such as lactic acid bacteria also predominate at low pH.

Water: Without water, Dehydration (loss of moisture) occurs and the life and growth processes of microorganisms slow down and may stop. The microorganisms might not be destroyed however. The use of salt or syrups (sugar) in various foods is a way of activating this process. These salts and sugars are crystals

that compete with the microorganisms for the available water that they need for survival.

It is now generally accepted that the water requirements of microorganisms should be defined in terms of the water activity (a_w) in the environment. This is a measure of the availability of water to microorganisms for metabolism (the processes of life). The (a_w) of pure water is 1.00, - a 22% salt solution has an (a_w) of 0.86 and a saturated salt solution is 0.75. The (a_w) value for most fresh foods is above 0.99.

Approximate Minimum (a_w) Values for Growth

<i>Organisms Groups</i>	<i>Water activity</i>
Most spoilage Bacteria	0.90
Most spoilage Yeast	0.88
Most Spoilage moulds	0.80

Oxygen: Microorganisms respire. That is, they get energy by breaking down chemicals, usually sugars, inside the cell. Aerobic organisms must use oxygen obtained from their environment (usually air) before they can produce energy for life and growth. Anaerobic organisms can produce this energy only in the absence of oxygen. Facultative organisms can respire in either aerobic or anaerobic conditions.

Control of microorganisms

Control of microorganisms is needed to prevent:

- The spread of disease and infection.
- The spoilage of foodstuffs.
- Contamination of food.

The most common ways of killing microorganisms are by heat and by chemicals. Other less common means include, irradiation, ultrasonic sound and very high pressure. Some bacteria, and almost all virus, yeast and mould cells are killed by a temperature of 60°C for 10 to 20 minutes.

Yeast and mould spores, and most other bacteria are destroyed at temperatures between 70 - 100°C for 5 to 10 minutes exposure. Bacterial spores however, are very difficult to destroy. Some for example, need at least 10 minutes at 100 to 120°C. The following terms are commonly used in cleaning:

- **Sterilisation** – The process of destroying or removing all microbial life.
- **Disinfection** – The killing of disease causing bacteria as well as other living microorganisms, but not usually bacterial spores. Disinfection does not necessarily kill all microorganisms, but reduces them to a level not usually harmful to health. In this group are the fungicides (kills fungi), bactericides (kills bacteria) and virucides (kills viruses).
- **Sanitising** – A term meaning that an article or surface is visibly clean and is free of disease producing organisms.

Quality Control

The general purpose of quality control is to ensure that a maximum amount of the product being processed reaches the desired level of quality with minimum variation and that this is achieved as economically as possible. The products of natural raw materials are never exactly the same, so control is necessary to keep product quality

within the standards set. Raw materials should be purchased from reliable suppliers who hold a current food manufacturer's registration.

Quality control generally involves inspections of three kinds :

- Raw materials
- Materials in process
- Finished product

If effective raw material and process controls are not put in place and only examination of the finished product is done, then quality control stops being a control and becomes merely an inspection. A good control system rejects substandard ingredients before the process begins and once it has begun, prevents wastage of good raw material.

Food Borne Disease

Since the nutrients in the foods we ingest are the very same nutrients that microbes thrive on, it is logical that the microbes are among our greatest competitors for the available organic food. For several reasons food borne diseases, or FBD, have always plagued man, and for that matter every other living animal on the planet.

Common Food Poisoning Illnesses

<i>Clostridium Perfringens</i>	
Foods involved	Contaminated poultry meat and meat products, especially stews, gravies and pies.
Main Symptoms	Abdominal pain, diarrhoea and nausea.
Onset of Illness	8 to 22 hours, (usually 10 to 12 hours).
Source	This organism is found in the waste of <i>Contd....</i>

Contd....

animals and man, and often in raw meat and in soil. It thrives in airless conditions and survives ordinary cooking.

<i>Salmonella</i>	
Foods involved	Contaminated meat and meat products, especially poultry. Custard, cream, milk and egg products, and salads.
Main Symptoms	Fever, headache, aching limbs, abdominal pain, nausea, diarrhoea, and sometimes vomiting.
Onset of Illness	6 to 72 hours (usually 12 to 36 hours).
Source	Salmonella bacteria are often present in the waste of man and animals, (especially rodents and poultry). This illness is infectious and can be spread to other people.

<i>Staphylococcus</i>	
Foods involved	Contaminated moist protein foods. Meat, eggs and fish products.
Main Symptoms	Abdominal pain, severe vomiting, diarrhoea, abdominal cramps, and sometimes collapse.
Onset of Illness	1 to 6 hours (usually 2 to 4 hours).
Source	Staphylococcal bacteria may come from infected sores, nasal secretions and skin (perspiration and hair). The toxin that causes illness can survive ordinary cooking.

<i>Campylobacter</i>	
Foods involved	Contaminated meat and meat products, especially poultry.
Main Symptoms	Contaminated water, and raw milk. Diarrhoea, abdominal pain, fever,

Contd....

Contd....

	nausea, and vomiting.
Onset of Illness	1 to 10 days (usually 3 to 5 days).
Source	Campylobacter bacteria are often present in the waste of man and animals (especially domestic animals and poultry). This illness is infectious and can be spread to other people.

Chemical Poisoning

Foods involved	All foods can be affected; (eg. soap powders/rat poison getting into dry food mixes; garden poison residues in soft drink bottles).
Main Symptoms	Abdominal pain, nausea, at times vomiting and diarrhoea. These symptoms may not be present for a lot of poisons— in these cases often the first symptom is of collapse.
Onset of Illness	Usually less than half an hour. Other food-borne diseases of note are Listeria, Yersinia and Cryptosporidium.

Listeria

Foods involved	Contaminated processed meats and meat products, raw milk, seafood, poultry and vegetables etc (eg coleslaw).
Main Symptoms	Normal host Acute/mild fever, influenza-like symptoms. At risk host Fever, intense headache, nausea, meningeal irritation and vomiting. Infection of the foetus, septicemia, meningitis, and still-birth.
Onset of Illness	3 days to 3 weeks.
Source	Listeria bacteria are commonly found in

Contd....

Contd....	soil, water, vegetation, domestic animals, and man. The illness, though infectious, is relatively rare.
At Risk Hosts	Pregnant women, the elderly, and those with lowered immune systems.

Yersinia

Foods involved	Contaminated meat and meat products, especially pork mince and tongue. Contaminated water, seafood and raw milk.
Main Symptoms	Under 5 yrs diarrhoea, (sometimes bloody). Over 5yrs abdominal pain (like appendicitis), also fever, joint pain sore throat and rash.
Onset of Illness	12 hrs to 11 days (usually 24 to 48 hours).
Source	Yersinia bacteria are often present in the waste of farm animals (especially pigs) and infected pets-(puppies and kittens) and man. This illness is infectious and can be spread to other people.

Cryptosporidium

Foods involved	Contaminated food and water, unpasteurised milk or fruit juices.
Main Symptoms	Diarrhoea (often watery), abdominal cramps/pain, and anorexia. Fever, nausea, and vomiting occur less often.
Onset of Illness	1 to 12 days (usually 7 days).
Source	Cryptosporidium parasites are often present in the waste of farm animals, poultry, pets and man. This illness is infectious and can be spread to other people.

in dirt and various forms of gore and muck, but our food, often taken from the partly rotted carcasses of long-dead creatures, was covered with even worse. No matter, since our ancestors were hungry—probably near to starving a good portion of the time—the niceties of sanitation were rarely observed. Rather, our ancestors bolted down any food (maggots and all) that fell into their fouled hands regardless of its condition. If they were really lucky they didn't get sick, if they were mildly unlucky they got a few cramps and a brief, but messy case of the runs and recovered. However, if they really had bad fortune they became violently ill and frequently died writhing in agony in their own vomit and excrement.

Secondly, many pathogens have evolved to take advantage of the gusto with which humans ingest unsanitary meals to gain entry into our nutrient-rich bodies by hitching a ride in our food for their own nefarious ends. Recent studies indicate that consumers are very concerned about the contamination of their food with dangerous microbes. In one survey 77% indicated that the fear of "germs" in their food was of greater concern than pesticide residues, product tampering, antibiotics in food or other safety risks. However, despite these concerns, studies show a significant lack of knowledge of consumers as to what constitutes safe food handling practices. These studies show:

1. Most consumers erroneously believe that foodborne illness is caused by food prepared commercially rather than in the home. However, data show that 80% of the food poisoning occurs in the home. While there are sporadic outbreaks of foodborne illness associated with commercial food products, studies indicate that foodborne illness are far more common in the home.

2. Many consumers are unaware that the most common foodborne illnesses in the US, caused by *Salmonella* and *Campylobacter*, may take several days to develop and often cause fevers.
3. Consumers often do not handle food safely at home as they are unaware of the importance of refrigeration, handwashing, and preventing cross-contamination between meats and uncooked foods in preventing foodborne illnesses in the home.
4. Consumers willingly change their habits when provided with the correct information.
5. Food poisoning kills ~9,000 Americans/year and sends 30 to 80 million to the doctor, emergency rooms or bathrooms with fever, diarrhea and cramps.
6. Bacteriological analysis indicates that it is better to eat food that has fallen in your toilet than food that has fallen into your kitchen sink.

Food Borne Diseases exist in two major categories; intoxications and infections. The former is the result of ingesting toxins produced by microbes that have grown on the food prior to it being eaten.

Botulism

Botulism is an intoxication that is caused by the ingestion of a virulent nerve toxin produced by the growth of the gram positive, obligate anaerobe, spore-former *Clostridium botulinum*. This bacterium appears to be a normal inhabitant of the soil, hence its ready contamination of most foods. It is able to grow in absence of oxygen in a wide variety of foods and in so doing produces a protein neural toxin, two to three grams (an amount equivalent to the quantity of salt in the average

salt shaker on your table) of which would be sufficient to kill every human on earth.

However, the organism will not grow in the presence of oxygen or nitrate salts and it does not produce the toxin at a pH below 4.7. Only one strain, which is found associated with marine organisms, is able to produce the toxin at refrigerator temperature. The toxin is destroyed by boiling it at 100°C for 10 to 15 min. However, the spore requires a temperature of 121°C for 15 min to kill it.

The toxin acts by binding to nerve junctions and destroying the nerve. The symptoms, which occur usually within 12 to 36 hours, but which can take up to 8 days to appear, classically consist of double vision, dizziness, inability to speak, breathe or swallow. Death often occurs due to the inability to breathe. The only treatment is the injection of *antitoxin* to the several varieties of the toxin. This treatment is only effective against free toxin, as once the toxin has bound to the nerves the damage is irreversible.

The entire canning process is built around insuring that all spores of this bacterium contaminating any canned food are destroyed in the sterilisation process. Industry has a sterling record in that deaths from commercial-botulism are very rare. This is influenced by the fact that once a product is known to contain botulism toxin none of that product is ever again purchased by a customer. The majority of botulism poisonings occur in Home-canned Foods prepared by grandma or your favourite aunt. Some interesting additional information about this disease is:

- Never feed raw honey to a child under the age of two because the botulism spores can grow in the immature gut and produce the toxin.

- The botulism toxin is being used to treat certain neurological conditions where nerves that shouldn't fire do. In these cases tiny quantities of the botulism toxin is injected into the nerve, which the toxin kills and cures the condition.
- Ducks and chickens often die from botulism poisoning by eating rotting material in which the bacterium has grown. However, vultures, which as you know, eat disgusting rotten, stinking carrion, are immune to the toxin through evolution.

Q Fever

This FBD is the result of infection by the gram negative, obligate intracellular bacterium *Coxiella burnetii*. This organism is associated with farm animals, with man usually considered to be an accidental victim; in fact it was first called the "wool cutters' disease" because Australian wool clippers frequently came down with it because of their close contact with sheep. It is still a common disease among those that work with farm animals where it is spread in the dust and through direct contact with animal carriers. It produces a flu-like disease that varies from being mild to very debilitating.

Although the majority of people who contact this disease recover, some strains of the bacterium are able to infect the heart, producing a fatal disease. Because it is highly infectious, the onset rapid and the disease debilitating, it has been studied as a biological warfare weapon. The microbe produces forms which are spore-like in their resistance to heat and drying. Because of the frequency of milk contamination by *C. burnetii* is considered a FBD and because of the heat-resistant nature of this bacterium, the temperature of the pasteurisation process was increased a few years ago to 72°C for 15 seconds to eliminate it from milk.

Staphylococcus Aureus

Staphylococcus aureus is a common inhabitant of the human body, being found on our skin and in our nose and is considered part of our natural flora. This bacterium interacts with humans in many ways. It is a common cause of *nosocomial infections* that frequently causes death in the patients it infects, it is a prevalent cause of severe skin infections like boils and impetigo, it is the etiological agent of Toxic-Shock Syndrome and it is one of the major causes of FBD in the world because of its intimate association with humans. This bacterium has a number of characteristics that contribute to its many roles.

Although it is not a spore-former, it does tolerate high temperatures better than most non-spore-formers. It is able to grow in high salt and sugar environments which allows it to survive and flourish on the human skin and in rich, sweet foods. It produces a wide variety of toxins, depending on the strain and it tends to carry a large number of antibiotic resistant plasmids. It is, in short, a formidable adversary. It generally produces FBD in "rich foods", such as cakes, pies, potato salad and custards.

The usual scenario involves food that was prepared in advance and improperly stored for a long time before being eaten. During this storage period the contaminating *S. aureus* (from the nose and hands of the individual who prepared the food) grow rapidly, often in such perfusion that their yellow colonies can be observed upon close examination. During growth the bacteria produce a number of potent toxins, one of which, called a superantigen, mimics a protein involved in our immune response. This superantigen acts by over stimulating the T-cells to produce prodigious quantities of interleukin 2 which, in turn, induces fever, malaise, nausea, vomiting, diarrhea and shock, which are the classical symptoms of

Staph food poisoning. This was discovered serendipitously by a physician who was treating cancer patients with interleukin 2 at different dosages and he noticed that at high doses they developed the classical food poisoning symptoms.

Staph food poisoning symptoms usually appear within 1 to 6 hours after ingestion and produces the symptoms described above. The disease is usually over within 24 hours and death is rare, usually limited to the very young or the old and infirmed.

Salmonella Gastroenteritis

Infections of humans by a variety of salmonella species is quite common in the US, being one of the most common causes of foodborne illnesses in the home. Salmonella are a genus of gram negative, small rod-shaped, non-spore-forming bacteria that are usually associated with animals, both wild and domestic. The problem occurs because many of the animal strains of salmonella, including ones that live in snakes, turtles and lizards, as well as chickens, horses, and turkeys, can infect humans and cause a severe gastroenteritis. This bacterium is released in the feces of the infected animal, thus when humans contract this disease it usually means that they have ingested fecal material due to unsanitary behaviour.

One of the most common sources of human salmonella infection occurs in the kitchen, both commercial and domestic. Unless the Highest Standards of sanitation are applied by knowledgeable individuals during the slaughter and preparation of food for human consumption, fecal material can contaminate the food. Such contamination can easily be spread to other foods via kitchen utensils, cutting boards, by contaminated hands or contact with contaminated work surfaces.

The salmonella are hardy microbes that are able to survive outside their hosts in water, on moist surfaces etc. for days to months, so cursory measures will not protect you from these dangerous pests. The most common sources of salmonella infection are fecal-contaminated animal meats such as turkey, chicken, beef etc. and eggs. Victims ingest the bacteria which invades the intestinal mucosa setting up an infection that produces inflammation of the intestine resulting in diarrhea, fever, cramps, nausea, abdominal pain, and vomiting (Gastroenteritis).

The disease onset occurs within 8 to 48 hours up to several days and the disease lasts 2 to 5 days to as long as several weeks. Treatment involves fluid/electrolyte replacement; antibiotics are only used to counter secondary infections. A serious, new form of Salmonella has appeared in the US in the past 10 years. This is a disease caused by Salmonella enteritidis. This bacterium has developed the ability to grow in the ovary or egg-producing organ, of chickens where it is deposited within the egg as it is being formed.

Other egg-related salmonella are found on the exterior of the egg where they can be killed by washing with bleach or hot soapy water, however this new strain can only be killed by thoroughly cooking all parts of the egg. That is, the bacterium is not eliminated from soft-boiled eggs or "over easy" eggs. The disease produced by *S. enteritidis* has caused a number of deaths and is a threat to anyone who fails to cook their eggs properly. In our household we always cook anything with egg in it thoroughly. The disease can only be prevented by testing of egg-producing flocks and the elimination of all the infected chickens.

One common problem is the way in which eggs are stored prior to placement on the store shelves. In a recent

investigation it was found that while the FDA rules specify that eggs should be stored at temperatures low enough to prevent the growth of *S. enteritidis* in them, many handlers do not adhere to these rules and examples of eggs being stored at room temperature in stores for several days were found. Perhaps you should inquire of your supermarket manager how their eggs are stored prior to being placed out for sale.

Clostridium Perfringens

Clostridium perfringens is a gram positive, obligate anaerobic, spore-former that is found in the gut of many animals, including humans. Besides producing a FBD, it is responsible for producing gas gangrene. As with salmonella, *C. perfringens* contamination occurs via the fecal-oral route during slaughtering and food preparation. However, this disease is an Intoxication and not an infection. As with Staphylococcus food poisoning, this FBD is usually the result of improper storage of food prepared in advance.

A holiday turkey is prepared, however during preparation the stuffing gets contaminated with *C. perfringens* spores (from poop) left on the turkey during their slaughter. The stuffing is subsequently packed tightly inside the turkey. Because stuffing is a excellent insulator, it may not get hot enough to kill the heat-resistant spores. At the first serving of the turkey no disease occurs, however once the stuffing, containing the live spores reaches room temperature the spores germinate and begin to grow rapidly while producing toxins.

As the stuffing sits out for several hours before being stored in the refrigerator in a large bowl, bacterial growth continues and since the large mass of stuffing may take

several hours to cool down in the refrigerator, growth continues for several more hours. When the "leftovers" are eventually served they contain toxic quantities of bacterial products and the eaters become ill. The illness strikes within 8 to 16 hours and produces profuse diarrhea. Most victims recover in 1 to 4 days and no treatment is usually necessary except for the very young or the elderly.

Escherichia Coli 0157:H7

This is a new kid on the block in that the disease produced by this bacterial strain was first recognised in 1982 during an outbreak of a FBD in the State of Washington. *E. coli* is a normal inhabitant of the human and animal gut and is the most studied bacterium on the planet. It is a gram negative, motile, plump, non-spore-forming rod. The numbers 0157 and H7 refer respectively to the antigenic characteristics of LPS (0157) and a flagella protein (H7). Although this strain had been first reported in 1975 it was not recognised as a FBD organism until the 1982 epidemic.

It is likely that there had been many previous outbreaks of food poisoning involving this bacterium, but the etiological agent had not been recognised and the FBD had been blamed on other organisms. This bacterium enter its victims via the fecal-oral route and produces an infection in the victim's intestine. 0157:H7 contains a plasmid that carries the gene for a virulent toxin. Once the infection is established, the toxin is released, causing Hemorrhagic Colitis and Hemolytic Uremic Syndrome.

The former results in damage of the intestine accompanied by bleeding and in severe cases destruction of the intestine that can only be stopped by surgical

removal of the infected tissue, often several feet of it. In the latter syndrome (HUS), the kidney is severely damaged and often completely destroyed. Death results from general organ failure due to a combination of the toxin effects and the failure of crucial organs.

The bacteria resides in food (and water) that is contaminated with fecal material, usually from cattle, although other sources may exist, including humans. The bacterium is easily killed by heat, but if products like hamburgers are not heated so that all parts of the patty reach a lethal temperature, the organism can survive to cause the disease. This bacterium has been cultured from raw milk, cheese, turkey roll sandwiches, chicken, pork, and raw vegetables; and recently in unpasteurised fruit juice. It has been spread between children at nursery schools due to unsanitary conditions.

The onset of the disease occurs 24 to 72 hours after ingestion. It varies from a mild gastroenteritis to the severe, often deadly course described above. Antibiotics seems to have little effect probably because once tissue damage sets in the blood supply is interrupted which prevents the drugs from reaching the infected sites. Surgical removal of the infected tissue is useful but very traumatic and it may not remove all the infection. It appears to be more severe in small children, possibly because they have not developed general low level immunity to *E. coli*. The extent and seriousness of this disease was painfully illustrated by events that took place in Japan during the summer of 1996. Almost 6,000 people became ill with 0157:H7 and to this day the source of the infection is unknown.

Traveller's Diarrhea and other *E.coli* Infections

The bacterium *E. coli* is the etiological agent of a whole

range of water and food borne diseases. One of the more common is a disease known as Traveler's Diarrhea. As its name implies this disease usually hits a traveler 1 to 3 days after he/she has arrived in a foreign country and consists of everything from a mild case of loose stools to a full blown case of painful diarrhea where one is confined to staying within 10 feet of a toilet until it passes. The symptoms usually disappear within 1 to 3 days and it is treated with anti-diarrhea drugs.

A traveler may suffer subsequent attacks as they visit other countries or they may never suffer an attack. The disease is thought to be a result of the strain specific nature of local *E. coli*. That is, because of a variety of environmental factors *E. coli* in different populations accumulate a unique series of genetic characteristics to which the infected population is adapted. However, a visitor who eats the local fecal-contaminated food and/or water picks up this unique regional-strain quickly. As it reproduces in the visitor's intestine it produces slightly different set of toxins to which the new host reacts unfavourably, as evidenced by their developing a case of the trots.

A number of other pathogenic *E. coli* strains have been identified each of which produces its characteristic intestinal disease. Some of these strains are virulent, and can produce a fatal disease while other produce relatively mild diseases. Each strain has been identified by a variety of characteristics including their antigenic "fingerprint", the plasmids they contain and now their DNA fingerprints. The *E. coli* induced diarrhea is a major, if not the major cause of death around the world of young babies. Usually the babies catch these organisms through drinking contaminated water, often used to make their formula. One of the unintended consequences of introducing baby formulas into underdeveloped countries

is an increase in infant death from diarrhea as the mother switch to formula made with contaminated water from breast feeding.

Campylobacter and Traveler's Diarrhea

The *Campylobacter* are aerobic/microaerophilic gram negative, motile helical bacteria. They were not recognised as human pathogens until 1970 and yet they are now known to be one of the major causes of gastroenteritis in the world. Some scientists now feel they have evidence that suggests that *Campylobacter* infections are the major cause of Traveler's Diarrhea. In the US they cause >2 million illnesses each year and thus are responsible for more foodborne illnesses than salmonella and *Shigella* combined. Their reservoir is the intestinal tract of cattle, sheep, dog, cats and poultry.

Humans become infected primarily through the ingestion of milk, meat or by contact with infected humans. The symptoms of the disease are diarrhea, sometimes bloody, abdominal pain, occasionally fever, and vomiting. The immunocompromised elderly, particularly those in institutions like nursing homes, are especially susceptible to this organism. That is, the combination of a susceptible population plus spread through a common kitchen and other facilities and personnel has resulted in institutional epidemics. The disease occurs 2-5 days after infection and lasts 7-10 days.

It is generally self-limiting in healthy patients, but is life-threatening in the infirmed. Antibiotics are effective in shortening the course of the disease. It is generally spread by poor sanitation within the home or institution, particularly via the kitchen. The high degree of contamination of poultry with *Campylobacter*, and other foodborne pathogens, requires that extra care be taken when preparing meals with poultry on the menu.

Prevention of Food Born Diseases

The prevention of FBD is theoretically easy but practically difficult due to the nature of humankind. Basically the elimination of foodborne diseases requires rigorous application of basic rules of hygiene and sanitation that everyone learns in kindergarten but frequently fails to apply in everyday life. Following are some of them:

- Wash your hands after pooping, especially if you're going to be handling food for yourself or anyone else.
- Wash your hands after playing with the dog, cat, ferret or alien, especially if you're going to be handling food for yourself or anyone else.
- Wash your hands after playing in the dirt, especially if you're going to be handling food for yourself or anyone else (Like me).
- Don't eat dirty or spoiled food (DUH!).
- Don't eat off of dirty dishes or utensils (double DUH!).
- Develop and practice good kitchen habits, including the following
 - Prepare all fresh meat dishes in a separate area of the kitchen.
 - Do not use utensils used to cut up meat on other foods, like salad makings; use separate cutting boards for meat and vegetables; colour coded ones help without washing adequately in-between.
 - Wash the meat preparation area (counter- and stovetops) and utensils with bleach or hot soapy water when finished.

- Wash hands well between working with meat and vegetables by scrubbing with soap for 30 seconds.
- Cook all foods, especially meats, thoroughly until there is no sign of redness in the center.
- Always assume that fresh food is contaminated, no matter how clean it looks or how well it is packaged and wash it thoroughly in hot, soapy water, removing all dirt, feces (DUH) etc.
- Never store food made with raw eggs (e.g. hollandaise sauce) at room temperature.
- Unless you want to have your name in the newspaper: “Latest Victim to Die From Botulism.....”
- Store all food that is prepared ahead of time in small batches in the refrigerator.
- Put away leftovers immediately after the meal in small portions that will cool quickly in the refrigerator.
- Avoid unpasteurised milk and milk products and juices.
- In your shopping cart keep meats bagged and separate from ready-to-eat foods; asked that meats be bagged separately at the checkout stand..
- Store meats separately from all other foods in the refrigerator.
- When eating out don’t order ground meat products and avoid salads.
- Don’t drink unchlorinated or any water not treated to remove bacteria/viruses.

Modern Issues of Food Safety

Modern issues of food safety revolve around two relatively new situations: Fast foods and Prepared Food.

Fast Foods

Typically, Fast Food businesses hire young, untrained people who don't understand the significance of routine sanitary measures and who work for low wages. Further, a large turnover in these jobs means that trained individuals are constantly being replaced with new, untrained personnel. As these businesses emphasise speed, profit, and service efficacy, matters relating to hygiene (e.g. hygiene training) can easily be overlooked or even viewed as an impediment to higher profits.

Fast Food services usually use bulk foods supplied from a central source over which they have no control. Although food services are regulated by state, federal and local health organisations trained inspectors are few, making oversight spotty at best. Since the report of unsafe food being supplied by a business or sold by a Fast Food franchise, usually causes a boycott of that business, and/or endless lawsuits, it is ultimately in the interest of the owners and employees of these businesses to maintain high standards of health and safety. However, the local staff have no control over how the bulk food suppliers prepare the food, where they obtain it, their sanitary conditions or the long distance carriers that transport the prepared food to them.

Bulk Food Adulteration

The issue of bulk food production and transport unfortunately offers ample opportunity for both accidental and intentional food adulteration. The vehicles that transport food are sometimes used to transport

hazardous or contaminated materials between carrying food. Since cleaning vehicles between jobs is expensive it may not be performed properly, if at all. Further, proper temperatures may not be maintained during food transportation; refrigeration can fail while the driver is asleep, excessively hot weather can overwhelm a refrigeration unit's capacity etc.

With increasing world trade, where foods of all kinds flow freely between countries, it is virtually certain that contaminated foods can rapidly spread globally. It has been noted that foodborne pathogens seem to appear virtually simultaneously all over the world. People expect fresh fruits and vegetables all year round so these produces are imported from countries that often have far less stringent sanitation rules and habits than we do. A single meal may contain food obtained from many countries so it is difficult to determine the source of contamination.

The Microwave Issue

The ubiquity of the Microwave in our kitchens also has added a set of new problems and concerns about the microbial safety of our food supplies. The supply of prepared, sterilised foods stored at room temperature on the supermarket shelves presents a potential source of microbial contamination. Frozen foods for microwave preparation have been available for a number of years and have been the source of some problems. Microwaves work by heating up the water molecules in the food. This means that if any portion of the food is dry, like potato skin, it may not be heated sufficiently to kill the pathogens residing there.

Another problem with microwaves is the uneven distribution of the microwaves. That is, depending on the

design of the particular brand of oven, not all parts of a food are heated equally thus some areas of the food fail to reach the temperatures which are lethal to pathogens in those portions of the food. A number of food poisoning cases involving frozen microwave foods have been traced to this problem. That is, in several cases parts or areas of the food were heated properly, but other parts had not reached sufficient temperature to kill contaminating microbes.

Microwave instructions inform the user that it is necessary to allow "Stand Time" so the heat from the heated portions can diffuse to the unheated areas; but the rushed nature of our busy lives makes it difficult to follow these instructions. However, it is better to take the time than to lose 5 feet of your small intestine and half your kidney function to *E. coli* 0157:H7 isn't it? Some medical authorities and nutritionists are concerned that, because of these problems, microwaves are not very safe. It is up to you to decide. At the very least you should find out how well your microwave model distributes the radiation and what foods should or should not be cooked in these instruments.

Developments in Food Safety and Quality Systems

Food quality is an important food manufacturing requirement, because the end consumers of food are highly vulnerable to any form of contamination that may occur during the manufacturing process. Many consumers also need to rely on the standards of manufacture, particularly to know what ingredients are present, due to dietary or nutritional requirements, which may be associated with religious dietary laws or medical conditions (e.g., diabetes, or allergies).

In addition to the quality applied to ingredients, there is also significant need to control the environment where food is produced to ensure that it is hygienic and exposed only to appropriate temperatures. Traceability of the source of ingredients and processes used to manufacture food are key techniques, as is the implementation of food labelling standards coupled with best-before dates. The most common result of poor food quality is foodborne illness, which is most often a result of contamination by bacteria followed by the food's being kept for too long at an elevated temperature favourable for bacterial growth.

Under optimal conditions, bacterial numbers can double every 20 minutes or so and, although the bacteria

may not themselves be harmful, they may produce potent toxins. Cooking at a temperature greater than 60 °C for an appropriate length of time kills bacteria, and chilling and freezing make bacteria dormant. However, if these processes are carried out too late, the toxins already existing may not be affected. Other forms of food preservation including canning, drying, salting, and pickling. Another way to help ensure food safety is to buy foods in containers that have been made Tamper-evident by using Induction Sealing.

Ensuring that the food supply is of a consistent and known quality is one of the main goals of agricultural policy; additional goals are to ensure that the food is wholesome, free of pesticides and other contaminants, and attractive. Other objectives of agricultural policy, such as crop intensive cultivation or introduction of genetically modified (GM) crops may not have full consumer support nor be of long-term value. There is a large consumer following for organically grown food that has not been exposed to any form of chemical treatment.

Traditional Quality Control

The traditional quality control programme was based on establishing effective hygiene control. Confirmation of safety and identification of potential problems was obtained by end-product testing. Control of hygiene was ensured by inspection of facilities to ensure adherence to established and generally accepted Codes of Good Hygiene Practices (GHP) and of Good Manufacturing Practices (GMP).

Codes of GHP/GMP are still the basis of food hygiene. However, codes—although being essential—only provide for the general requirements without considering the specific requirements of the food and the

processing of specific foods. Also the requirements are often stated in very imprecise terms such as "satisfactory", "adequate", "acceptable", "suitable", "if necessary", "as soon as possible" etc. This lack of specifics leaves the interpretation to the inspector, who may place too much emphasis on relatively unimportant matters. He may fail in distinguishing between "what is nice and what is necessary" and consequently increase the cost of the programme without reducing the hazards.

Perhaps one of the most common mistakes that many inspection services and some food companies make is to rely on end-product testing. Very often this has been the only quality and safety assurance system applied. Samples have been taken randomly from the day's production, and examined in detail in the laboratory. There are several problems related to this procedure:

- is costly. A well equipped laboratory will be needed as well as trained personnel. The running costs of a laboratory is high. Also, the cost of products "lost" to testing may be very high;
- the results are retrospective, and all cost and expenses have already been incurred if any hazards are identified in the end-product testing programme. What is needed is a preventive system, where safety hazards are anticipated and safety is built into the product right from the start;
- it may take several days before results from end-product testing are available;
- the chances of finding a hazard will be variable, but most often very low. Nevertheless, the hard work of sampling and testing will give a sensation of "being in control" and create a strong but false sense of security.

It is important to understand the ineffectiveness and limitations in using end-product sampling and testing to ensure product safety. In most cases there is no test that give an absolutely accurate result with no false positives and no false negatives. This is certainly the case for all microbiological testing. Furthermore, there are the principles of sampling and the concept of probability to consider.

Principles of Sampling

The number, size and nature of the samples taken for analysis greatly influence the results. In some instances it is possible for the analytical sample to be truly representative of the "lot" sampled. This applies to liquids such as milk and water. However, in cases of lots or batches of food this is not the case, and a food lot may easily consist of units with wide differences in (microbiological) quality. Even within the individual unit (i.e. a retail pack) the hazard (i.e. the presence of pathogens) can be very unevenly distributed, and the probability of detecting may be very low (Table 1).

Table 1. Detection probabilities – end-product testing of milk powder contaminated with Salmonella.

Contamination rate	Number of random samples	Probability of detection	
Homogenously contaminated	5 cells/kg	10	71%
	1 cell/kg	10	22%
Heterogeneously contaminated	5 cells/kg in 1% of batch	10	<2%
	10 ⁴ cells/kg in 1% of batch	10	<15%

In this example, a contamination rate of *Salmonella* at 5 cells/kg and assuming the contamination is restricted to 1% of the batch, the probability of detecting the hazard by taking 10 samples of 25 g would be lower than 2%. If

Relative Proportion of sample units in a lot

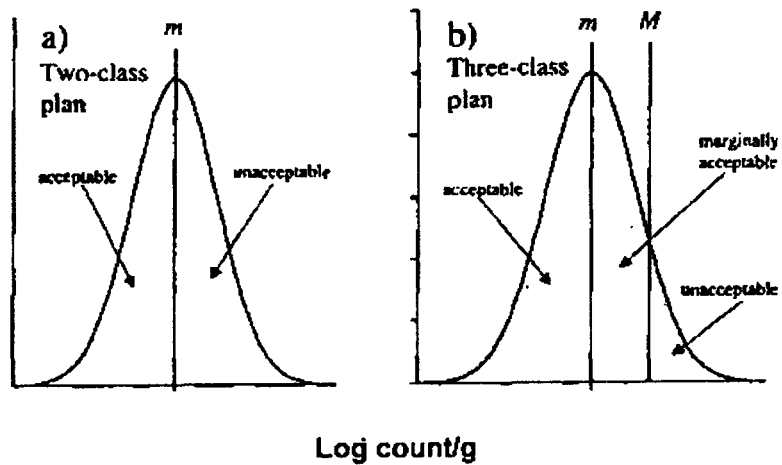


Figure 1. Two- and three-class attributes plans.

the contamination with *Salmonella* is homogeneously distributed at the same rate, probability of detection would increase to 71%.

A sampling plan (Attributes plan) can be based on positive or negative indications of a micro organism. Such a plan is described by the two figures "n" (number of sample units drawn) and "c" (maximum allowable number of positive results). In a 2-class attributes sampling plan, each sample unit is then classified into acceptable or non-acceptable. In some cases the presence of an organism (i.e. *Salmonella*) would be unacceptable. In other cases, a boundary is chosen, denoted by "m", which divides an acceptable count from an unacceptable. The 2-class sampling plan will reject a "lot" if more than "c" out of "n" samples tested are unacceptable.

In a 3-class sampling plan "m" separates acceptable counts from marginally acceptable counts and another figure "M" is indicating the boundary between marginally acceptable counts and unacceptable counts as shown in Figure 1.

The safety which can be obtained with such sampling plans depends on the figures chosen for "c" and "n". This can be illustrated with the so-called operating characteristic curves which are demonstrating the statistical properties of such plans (Figure 2).

The figures show that the greater the number of defective units (P_d), the lower is the probability of acceptance (P_a) of the lot. It is further demonstrated, that high value of "n" and low value of "c" reduces the risk of accepting lots with same number of defective units. It can be seen that testing of foods for the presence of contaminants offers very little protection even when large numbers of samples are examined as also shown in Table 2.

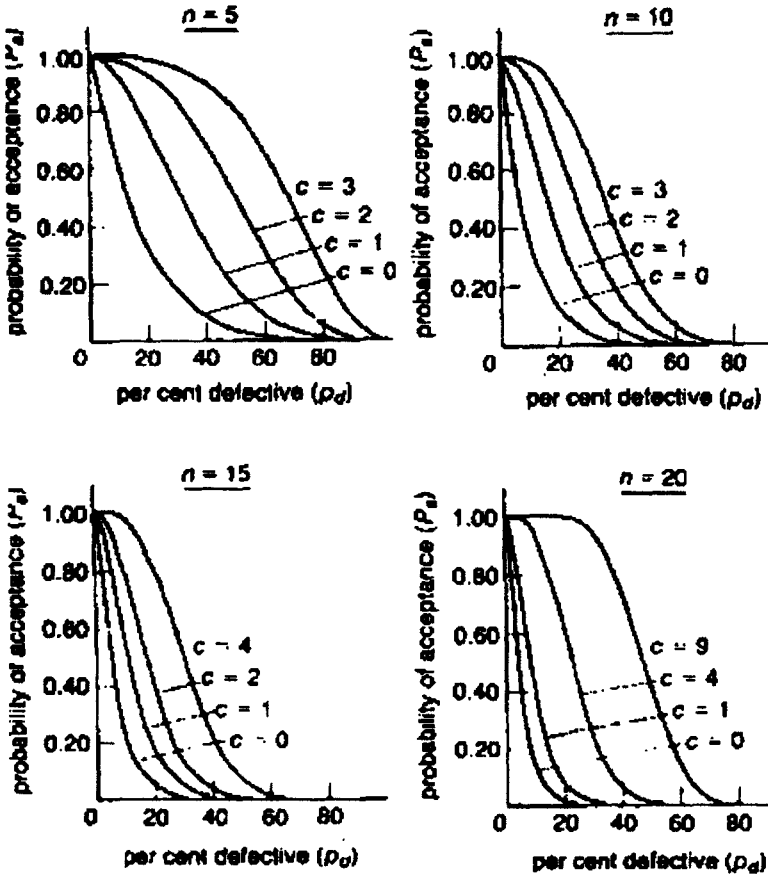


Figure 2. Operating characteristic curves for different sample sizes (n) and different criteria of acceptance (c) for 2-class attributes plan

Table 2 clearly shows, that lot testing is not effective when defect rates are low. A product safety defect rate of 1% is absolutely intolerable in many food operations. Potentially, it represents 10 000 unsafe units per one

million units manufactured. More than 3 000-5 000 units would need to be sampled and tested in order to detect a 1% defect rate with 95% or 99% probability.

Table 2. Effect of lot quality (% defective in a lot) on the probability of acceptance (%) for different 2-class sampling plans.

% defective samples in lot	probability of acceptance (%) given sampling plans with a total of "n" samples and allowance of "c" defect samples			
	n=1, c=0	n=5, c=0	n=10, c=0	n=60, c=0
1	99.0	95.1	90.4	54.7
2	98.0	90.4	81.7	30.0
5	95.0	77.4	59.9	4.6
10	90.0	59.1	34.9	0.18
20	80.0	32.8	10.7	0.00015

It is evident, that even the most elaborate sampling and testing of end-product cannot guarantee safety of the product. There is no way to avoid some degree of risk and error in each acceptance and each rejection of lots unless the entire lot is tested, in which case no edible food will be left.

Modern Quality Control

To the uninitiated, and also the initiated, there may seem to be a whole host of different options or methods for ensuring the safety and quality of food products. The situation is not helped by the acronyms arising from these methods i.e. ISO, GMP, GHP, HACCP, TQM, etc. seeming to have a life of their own and coming into modern usage as words in themselves, and sometimes used without an understanding of what they mean.

Table 3. *Categorisation of items to be managed in a company.*

<i>Management concern</i>	<i>Items to be managed</i>
Technical	Intrinsic quality of fish (taste, smell, and texture); safety; spoilage/freshness; grading; packaging; nutritional; authenticity; shelf life, etc.
Managerial	Administrative systems; customer relations; promotion; delivery commitments; invoicing and payment, etc.
Environmental	Waste and water management; noise pollution; odeurs; pollutants, etc.

Following are the description of some important methods to manage quality and/or safety.

- Good Hygienic Practices (GHP) / Good Manufacturing Practice (GMP) or Sanitation Standard Operating Procedures (SSOP) or prerequisite programmes
- Hazard Analysis Critical Control Point (HACCP)
- Quality Control (QC)
- Quality Assurance (QA) / Quality Management (QM)
- ISO standards
- Quality Systems
- Total Quality Management (TQM).

The food safety tools and their relationship is shown in Figure 3.

Good Hygienic Practices / Good Manufacturing Practices

The terms GHP and GMP refer to measures and requirements which any establishment should meet to

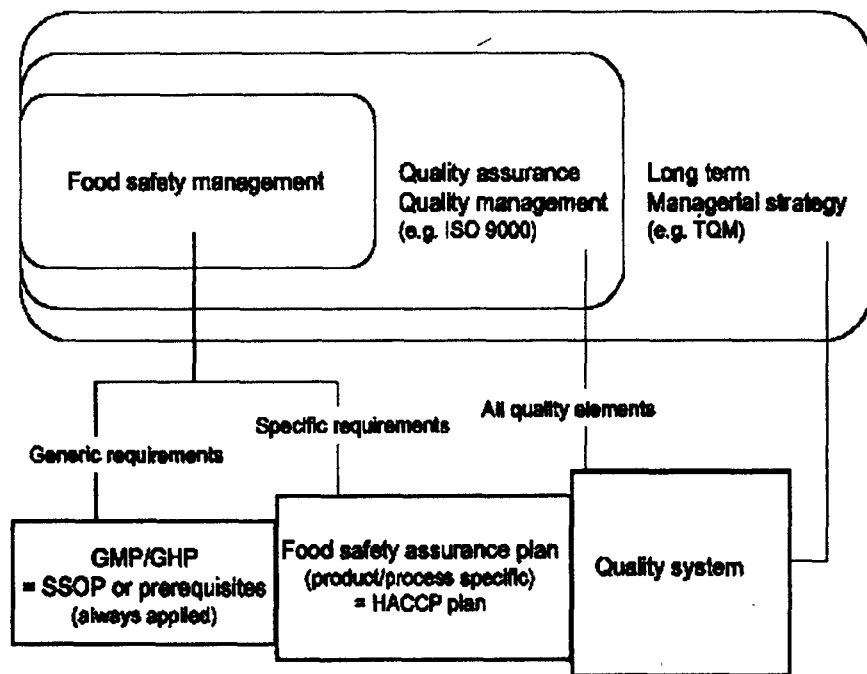


Figure 3. Food safety tools: an integrated approach

produce safe food. These requirements are prerequisites to other and more specific approaches such as HACCP, and are often now called prerequisite programmes. In recent years the term Standard Sanitary Operating Procedures (SSOP) has also been used in the US to encompass basically the same issues, i.e. best practices.

Hazard Analysis Critical Control Point

Hazard Analysis Critical Control Point (HACCP) is a systematic approach which identifies, evaluates, and controls hazards which are significant for food safety. HACCP is legislated in many countries, including the USA and the European Union. The combination of GHP/GMP and HACCP is particularly beneficial in that the efficient application of GHP/GMP allows HACCP to focus on the true critical determinants of safety.

Quality Control

It is an important subset of any quality assurance system and is an active process that monitors and, if necessary, modifies the production system so as to consistently achieve the required quality. It can be argued that QC is used as part of the HACCP system, in terms of monitoring the critical control points in the HACCP plan. However, traditional QC is much broader than purely this focus on critical control points for safety systems.

Quality Assurance/Quality Management

This can be defined as all the activities and functions concerned with the attainment of quality in a company. In a total system, this would include the technical, managerial and environmental aspects as alluded to above. The best known of the quality assurance standards is ISO 9000 and for environmental management, ISO 14000.

The term quality management is often used interchangeably with quality assurance. In the seafood industry, the term quality management has been used to focus mostly on the management of the technical aspects of quality in a company, for instance, the Canadian Quality Management Programme which is based on HACCP but covers other technical issues such as labelling.

ISO Standards

The International Organisation for Standardisation (ISO) in Geneva is a worldwide federation of national standards bodies from more than 140 countries. ISO's work results in international agreements which are published as International Standards. The vast majority of ISO standards are highly specific to a particular product, material, or process. However, two standards, ISO 9000 and ISO 14000, mentioned above, are known as generic management system standards.

Over half a million ISO 9000 certificates have been awarded in 161 countries and economies around the world and in 2001 alone over 100 000 certificates were awarded, 43% of which were the new ISO 9001:2000 certificate. Historically, the ISO 9000 series of standards of relevance to the seafood industry included:

- ISO 9001 Quality systems—Model for quality assurance in design/ development, production, installation and servicing
- ISO 9002 Quality systems—Model for quality assurance in production and installation.

More recently, the new ISO 9001:2000 certificate is the only ISO 9000 standard against whose requirements a quality system can be certified by an external agency and

replaces the old ISO 9001, 9002 and 9003 with one standard. It is important to note that the ISO 9000 standards relate to quality management with customer satisfaction as the end point, and that they do not specifically refer to technical processes only. ISO 9000 gives an assurance to a customer that the company has developed procedures for all aspects of the company's business.

ISO 14000 is primarily concerned with environmental management. Introduced much later than the ISO 9000 series, there are now over 35 000 ISO 14000 certificates awarded in 112 countries or economies of the world. During 2001, nearly 14 000 certificates were awarded, around 40% of the total awarded since the introduction of the standard. In most countries, implementation of ISO 9000 quality management systems or ISO 14000 environmental systems are voluntary.

Quality Systems

This term covers organisational structure, responsibilities, procedures, processes and the resources needed to implement comprehensive quality management. They are intended to cover all quality elements. Within the framework of a quality system, the prerequisite programme and HACCP provides the approach to food safety.

Total Quality Management (TQM)

TQM is an organisation's management approach, centred on quality and based on the participation of all its members and aimed at long-term success through customer satisfaction and benefits to the members of the organisation and to society. Thus TQM represents the organisations' "cultural" approach and together with the

quality systems provides the philosophy, culture and discipline necessary to commit everybody in the organisation to achieve all the managerial objectives related to quality.

Analysis of Risk

The management and control of (sea) food borne diseases is carried out by several groups of people. It involves experts assessing the risk, i.e. providing the epidemiological, microbiological and technological data about the pathogenic agent, the food, the host etc. It involves risk managers who at government level have to decide what level of risk society will tolerate and risk managers in both industry and government that have to implement procedures to control the risk. At industry level this is done using GHP and HACCP procedures as described below.

The term “risk analysis” is the process underlying development of food safety standards. It consists of three separate but integrated parts, namely risk assessment, risk management and risk communication. The risk analysis process must be open and at every step all stakeholders should be allowed to participate and comment. It has been seen as important that there is a separation between the risk management and the risk assessment.

The risk assessment is a science based evaluation whereas risk management (at government level) also involves a range of societal issues. The objective of the rules that govern international trade with food, the WTO/SPS agreement, is to permit countries to set certain safety measures for their population and ask that imported foods allow the same level of public health protection. To justify and compare the levels of public

health protection and food safety measures, risks must be analysed using the risk assessment techniques described by Codex. Analysis of risk includes the following steps:

- identification of a food safety problem
- assessment of the risk
- establish a public health goal, e.g. expressed as a food safety objective
- implement risk management decisions
- establish performance criteria
- establish process and product criteria
- establish acceptance criteria
- communication of risk.

Identification of Food Safety Problem: A food safety problem may be identified either through a sudden change in disease frequency, i.e. epidemiological data indicate a sudden rise in a particular disease, or the hazard analysis carried out as part of the HACCP system may indicate reason for concern. This could be caused by implementation of new processing technologies, or by changes occurring in population composition.

Risk Assessment: Evaluating the risk associated with the problem involves estimating the severity of the disease and the likelihood of occurrence. Basically, the magnitude of the problem to public health is being determined. This evaluation of risk can be done by just one or two experts, by an expert panel or a so-called quantitative risk assessment may be conducted. Whether one or the other is chosen depends on the urgency of the matter—sometimes a risk management decision has to be made immediately—and of the complexity and its implications for international trade. The term

"quantitative risk assessment" can be a bit misleading, since any evaluation of risk requires considerations of quantitative aspects.

However, it has recently been used to describe a lengthier and structured process in which the impact of different factors from farm to fork that contribute to risk are quantified. Typically this process involves the use of mathematical modelling at several steps using Monte Carlo simulations. An example of a quantitative risk assessment is the FAO/WHO work on *Listeria monocytogenes* in ready to eat foods. One result of the risk assessment is the graphical representation of dose-response curve in which the likelihood of disease is presented as a function of levels of *L. monocytogenes* consumed (Figure 4).

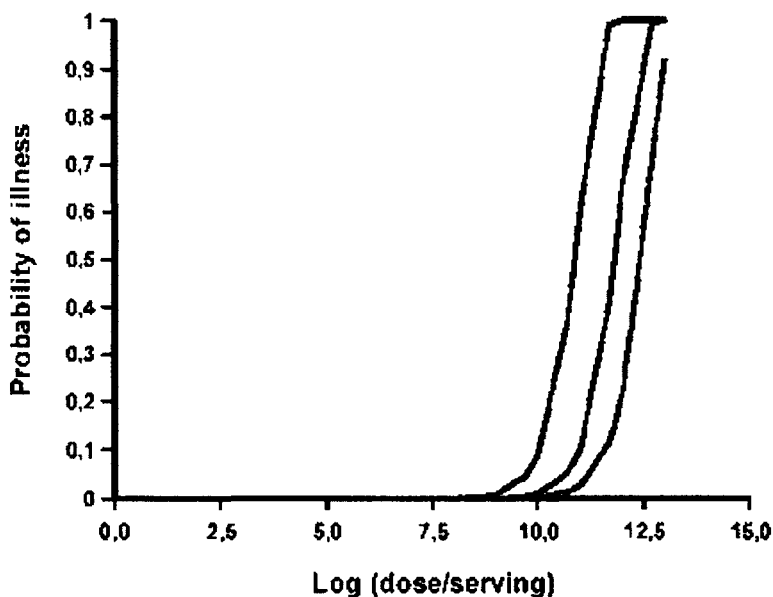


Figure 4. Simulated dose-response function for *Listeria monocytogenes* in ready to eat foods for consumers in the high risk group.

The graph clearly demonstrates that the risk of disease is related to consumption of high numbers of the organism. However, if the risk is expressed as the log value it becomes evident that there is no threshold value below which the risk disappears but even a few cells do carry some, albeit very low, level of risk. This curve can be used to determine how many cases a particular level of consumption of a pathogen leads to.

Based on the consumption pattern and data from the FDA/FSIS risk assessment as well as the risk characterisation curve from the same study, one can predict how many cases are the result of different levels at point of consumption.

Determining a Public Health Goal: When determining a public health goal, risk is most often expressed as a number of cases of illness per capita per year. For instance, the level of listeriosis cases in the US is 0.5 per 100 000 of the population per year and recently, the White House announced that this had to be reduced to 0.25 cases per 100 000 of the population per year.

Several terms exist for such public health goals. Ideally, the goal would be to reduce all (sea)food borne diseases to "zero risk", however, this is technically and financially not possible. It is important to understand that there is no such thing as "absence of risk". Therefore, the public health goal is expressed using different terms such as "appropriate level of protection" (ALOP). Realising that no risk is really ever appropriate, the ICMSF has suggested to use the term "tolerable level of risk" (TLR).

Food Safety Objective: Levels of disease attack rate are difficult to measure and target by food managers in government and industry and therefore the term Food Safety Objective (FSO) has been introduced. The FSO translates risk into a measurable goal and is expressed as

the concentration or frequency of a hazard in a food that is considered "safe" or meeting the level of protection/risk set by society. The FSO has been used in broad terms by several but was explicitly defined by the ICMSF. If a quantitative risk assessment has been conducted, the FSO is simply the translation for the Y-axis to the X-axis.

FSOs can—and are often—set even when quantitative risk assessments and the risk characterisation curve are not available. Investigations of food borne diseases, epidemiological surveillance programmes, industry records and knowledge of the influence of food processing parameters can provide information about which foods cause adverse health effects, which pathogens are implicated, and, to some extent, which levels of pathogens are involved. In effect, the setting of microbiological criteria for foods has been and is an indirect way of setting an FSO—and thus implies a desired public health goal. Many examples of this are present. One is the standard for *Staphylococcus aureus* in cooked crustaceans ($n=5$, $c=2$, $m=100/\text{g}$ and $M=1000/\text{g}$). This criteria contains an evaluation of the risk related to the concentration of the hazard.

It is important to realise that FSOs are not equivalent to microbiological criteria but that, if appropriate, criteria can be derived from FSOs. An FSQ is a public health goal whereas a microbiological criteria defines acceptability of a food product or a lot of foods and should indicate sampling plan, method, number of units that must conform etc. An example of an FSO is a concentration of 100 *L. monocytogenes* per gram at point of consumption for ready-to-eat-foods. Criteria for *L. monocytogenes* at earlier points in the chain will typically be lower than the 100 cfu/gram.

It must be evaluated if the FSO as expressed by risk managers is achievable. If not, it must be decided

- (i) if changes in the industry has to be enforced,
- (ii) if the product should be taken off the market or
- (iii) if the product should be labelled as carrying a risk.

Examples of such procedures are

- (i) the mandatory pasteurisation of milk,
- (ii) the ban of tetrodotoxin containing fish species for the EU market and
- (iii) the notice by restaurants in several US states that eating raw oysters may be detrimental to health.

Implement Risk Management Decisions: When a public health goal has been set, it is the responsibility of risk managers in industry (and government) that measures are taken to control the risk. With respect to foodborne pathogens, the risk can in principle be controlled at three levels:

- the initial level of the pathogen
- reducing the level of the pathogen or
- preventing increase of the pathogen.

The primary tools available to the food industry to control safety risks are GHP and HACCP programmes. Incorporated into these programmes may be various processes and criteria that ensure that the FSO is met.

A *performance criteria* describes the outcome of a process or step. This can for instance be that a canning procedure should ensure a 12D kill of *C. botulinum* spores or that only 3% of freshly produced cold-smoked salmon must contain *L. monocytogenes*.

Process and product criteria are statements of values for specific processes, such as time x temperature combinations during hot-smoking, or values such as NaCl-% and pH in the product. For instance, the control of *C. botulinum* in lightly preserved fish is not carried out by sampling and testing for *C. botulinum* but by ensuring that the combination of salt and temperature is sufficient to prevent growth.

Acceptance criteria are measurements or statements of conditions that distinguish acceptable from non-acceptable products. These may be based on sensory evaluations, on chemical measurements and may in some cases be *microbiological criteria*. These should specify the agent to be measured, the number of samples and the method used. As described later, sampling and microbiological testing is best used for detection of high concentrations or frequencies of microorganisms.

Risk Communication: An integral, and very important step, in all stages of a risk analysis is the communication of risk to stakeholders; including industry and consumers. An important part of the risk communication is using the findings of the risk assessment for training purposes and in the process of setting specifications.

Application of Microbiological Criteria for Foods

A microbiological criterion for food defines the acceptability of a product or a food lot, based on the absence or presence, or number of microorganisms including parasites, and/or quantity of their toxins/metabolites, per unit(s) of mass, volume, area or lot. A microbiological criterion consists of:

- a statement of the microorganisms of concern and/or their toxins/metabolites and the reason for that concern;
- the analytical methods for their detection and/or quantification;
- a plan defining the number of field samples to be taken and the size of the analytical unit;
- microbiological limits considered appropriate to the food at the specified point(s) of the food chain;
- the number of analytical units that should conform to these limits.

A microbiological criterion should also state:

- the food to which the criterion applies;

- the point(s) in the food chain where the criterion applies; and
- any actions to be taken when the criterion is not met.

When applying a microbiological criterion for assessing products, it is essential, in order to make the best use of money and manpower, that only appropriate tests be applied to those foods and at those points in the food chain that offer maximum benefit in providing the consumer with a food that is safe and suitable for consumption.

Microbiological criteria may be used to formulate design requirements and to indicate the required microbiological status of raw materials, ingredients and end-products at any stage of the food chain as appropriate. They may be relevant to the examination of foods, including raw materials and ingredients, of unknown or uncertain origin or when other means of verifying the efficacy of HACCP-based systems and Good Hygienic Practices are not available.

Generally, microbiological criteria may be applied to define the distinction between acceptable and unacceptable raw materials, ingredients, products, lots, by regulatory authorities and/or food business operators. Microbiological criteria may also be used to determine that processes are consistent with *the General Principles of Food Hygiene*.

Microbiological criteria can be used to define and check compliance with the microbiological requirements. Mandatory microbiological criteria shall apply to those products and/or points of the food chain where no other more effective tools are available, and where they are expected to improve the degree of protection offered to

the consumer. Where these are appropriate they shall be product-type specific and only applied at the point of the food chain as specified in the regulation.

In situations of non-compliance with microbiological criteria, depending on the assessment of the risk to the consumer, the point in the food chain and the product-type specified, the regulatory control actions may be sorting, reprocessing, rejection or destruction of product, and/or further investigation to determine appropriate actions to be taken.

In addition to checking compliance with regulatory provisions microbiological criteria may be applied by food business operators to formulate design requirements and to examine end-products as one of the measures to verify and/or validate the efficacy of the HACCP plan. Such criteria will be specific for the product and the stage in the food chain at which they will apply. They may be stricter than the criteria used for regulatory purposes and should, as such, not be used for legal action.

Microbiological criteria are not normally suitable for monitoring Critical Limits as defined in *Hazard Analysis and Critical Control Point System and Guidelines for its Application*. Monitoring procedures must be able to detect loss of control at a Critical Control Point (CCP). Monitoring should provide this information in time for corrective actions to be taken to regain control before there is a need to reject the product. Consequently, on-line measurements of physical and chemical parameters are often preferred to microbiological testing because results are often available more rapidly and at the production site.

A microbiological criterion should be established and applied only where there is a definite need and where its application is practical. Such need is demonstrated, for

example, by epidemiological evidence that the food under consideration may represent a public health risk and that a criterion is meaningful for consumer protection, or as the result of a risk assessment. The criterion should be technically attainable by applying Good Manufacturing Practices. To fulfil the purposes of a microbiological criterion, consideration should be given to:

- the evidence of actual or potential hazards to health;
- the microbiological status of the raw material(s);
- the effect of processing on the microbiological status of the food;
- the likelihood and consequences of microbial contamination and/or growth during subsequent handling, storage and use;
- the category(s) of consumers concerned;
- the cost/benefit ratio associated with the application of the criterion; and
- the intended use of the food.

The number and size of analytical units per lot tested should be as stated in the sampling plan and should not be modified. However, a lot should not be subjected to repeated testing in order to bring the lot into compliance.

Microbiological Aspects of Criteria

The microorganisms included in a criterion should be widely accepted as relevant—as pathogens, as indicator organisms or as spoilage organisms—to the particular food and technology. Organisms whose significance in the specified food is doubtful should not be included in a criterion. The mere finding, with a presence-absence test, of certain organisms known to cause foodborne illness

(e.g. *Clostridium perfringens*, *Staphylococcus aureus* and *Vibrio parahaemolyticus*) does not necessarily indicate a threat to public health.

Where pathogens can be detected directly and reliably, consideration should be given to testing for them in preference to testing for indicator organisms. If a test for an indicator organism is applied, there should be a clear statement whether the test is used to indicate unsatisfactory hygienic practices or a health hazard.

Microbiological Methods

Whenever possible, only methods for which the reliability has been statistically established in comparative or collaborative studies in several laboratories should be used. Moreover, preference should be given to methods which have been validated for the commodity concerned preferably in relation to reference methods elaborated by international organisations. While methods should be the most sensitive and reproducible for the purpose, methods to be used for in-plant testing might often sacrifice to some degree sensitivity and reproducibility in the interest of speed and simplicity. They should, however, have been proved to give a sufficiently reliable estimate of the information needed.

Methods used to determine the suitability for consumption of highly perishable foods, or foods with a short shelf-life, should be chosen wherever possible so that the results of microbiological examinations are available before the foods are consumed or exceed their shelf-life. The microbiological methods specified should be reasonable with regard to complexity, availability of media, equipment etc., ease of interpretation, time required and costs.

Microbiological Limits

Limits used in criteria should be based on microbiological data appropriate to the food and should be applicable to a variety of similar products. They should therefore be based on data gathered at various production establishments operating under Good Hygienic Practices and applying the HACCP system. In the establishment of microbiological limits, any changes in the microflora likely to occur during storage and distribution (e.g. decrease or increase in numbers) should be taken into account.

Microbiological limits should take into consideration the risk associated with the microorganisms, and the conditions under which the food is expected to be handled and consumed. Microbiological limits should also take account of the likelihood of uneven distribution of microorganisms in the food and the inherent variability of the analytical procedure. If a criterion requires the absence of a particular microorganism, the size and number of the analytical unit (as well as the number of analytical sample units) should be indicated.

Sampling Plans, Methods and Handling

A sampling plan includes the sampling procedure and the decision criteria to be applied to a lot, based on examination of a prescribed number of sample units and subsequent analytical units of a stated size by defined methods. A well-designed sampling plan defines the probability of detecting microorganisms in a lot, but it should be borne in mind that no sampling plan can ensure the absence of a particular organism. Sampling plans should be administratively and economically feasible. In particular, the choice of sampling plans should take into account:

- risks to public health associated with the hazard;
- the susceptibility of the target group of consumers;
- the heterogeneity of distribution of microorganisms where variables sampling plans are employed; and
- the Acceptable Quality Level and the desired statistical probability of accepting a non-conforming lot.

For many applications, 2-or 3-class attribute plans may prove useful. The statistical performance characteristics or operating characteristics curve should be provided in the sampling plan. Performance characteristics provide specific information to estimate the probability of accepting a non-conforming lot.

The sampling method should be defined in the sampling plan. The time between taking the field samples and analysis should be as short as reasonably possible, and during transport to the laboratory the conditions (e.g. temperature) should not allow increase or decrease of the numbers of the target organism, so that the results reflect—within the limitations given by the sampling plan—the microbiological conditions of the lot.

The test report shall give the information needed for complete identification of the sample, the sampling plan, the test method, the results and, if appropriate, their interpretation.

Risk Assessment of Microbiological Hazards

Risks from microbiological hazards are of immediate and serious concern to human health. Microbiological risk analysis is a process consisting of three components: Risk assessment, risk management, and risk communication, which has the overall objective to ensure public health

protection. The microbiological risk assessment process should include quantitative information to the greatest extent possible in the estimation of risk.

General Principles

1. Microbiological risk assessment should be soundly based upon science.
2. There should be a functional separation between risk assessment and risk management.
3. Microbiological risk assessment should be conducted according to a structured approach that includes hazard identification, hazard characterisation, exposure assessment, and risk characterisation.
4. A microbiological risk assessment should clearly state the purpose of the exercise, including the form of risk estimate that will be the output.
5. The conduct of a microbiological risk assessment should be transparent.
6. Any constraints that impact on the risk assessment such as cost, resources or time, should be identified and their possible consequences described.
7. The risk estimate should contain a description of uncertainty and where the uncertainty arose during the risk assessment process.
8. Data should be such that uncertainty in the risk estimate can be determined; data and data collection systems should, as far as possible, be of sufficient quality and precision that uncertainty in the risk estimate is minimised.
9. A microbiological risk assessment should explicitly consider the dynamics of microbiological growth, survival, and death in foods and the complexity of

the interaction between human and agent following consumption as well as the potential for further spread.

10. Wherever possible, risk estimates should be reassessed over time by comparison with independent human illness data.
11. A microbiological risk assessment may need reevaluation, as new relevant information becomes available.

The elements of risk analysis are: Risk assessment, risk management, and risk communication. The functional separation of risk assessment from risk management helps assure that the risk assessment process is unbiased. However, certain interactions are needed for a comprehensive and systematic risk assessment process. These may include ranking of hazards and risk assessment policy decisions.

Where risk management issues are taken into account in risk assessment, the decision-making process should be transparent. It is the transparent unbiased nature of the process that is important, not who is the assessor or who is the manager. Whenever practical, efforts should be made to provide a risk assessment process that allows contributions by interested parties.

Contributions by interested parties in the risk assessment process can improve the transparency of the risk assessment, increase the quality of risk assessments through additional expertise and information, and facilitate risk communication by increasing the credibility and acceptance of the results of the risk assessment. Scientific evidence may be limited, incomplete or conflicting. In such cases, transparent informed decisions will have to be made on how to complete the risk assessment process. The importance of using high quality

information when conducting a risk assessment is to reduce uncertainty and to increase the reliability of the risk estimate.

The use of quantitative information is encouraged to the extent possible, but the value and utility of qualitative information should not be discounted. It should be recognised that sufficient resources will not always be available and constraints are likely to be imposed on the risk assessment that will influence the quality of the risk estimate. Where such resource constraints apply, it is important for transparency purposes that these constraints be described in the formal record. Where appropriate, the record should include an evaluation of the impact of the resource constraints on the risk assessment.

At the beginning of the work the specific purpose of the particular risk assessment being carried out should be clearly stated. The output form and possible output alternatives of the risk assessment should be defined. Output might, for example, take the form of an estimate of the prevalence of illness, or an estimate of annual rate or an estimate of the rate of human illness and severity per eating occurrence. The microbiological risk assessment may require a preliminary investigation phase. In this phase, evidence to support farm-to-table modelling of risk might be structured or mapped into the framework of risk assessment.

Hazard Identification

For microbial agents, the purpose of hazard identification is to identify the microorganisms or the microbial toxins of concern with food. Hazard identification will predominately be a qualitative process. Hazards can be identified from relevant data sources. Information on

hazards can be obtained from scientific literature, from databases such as those in the food industry, government agencies, and relevant international organisations and through solicitation of opinions of experts.

Relevant information includes data in areas such as: clinical studies, epidemiological studies and surveillance, laboratory animal studies, investigations of the characteristics of microorganisms, the interaction between microorganisms and their environment through the food chain from primary production up to and including consumption, and studies on analogous microorganisms and situations.

Exposure Assessment

Exposure assessment includes an assessment of the extent of actual or anticipated human exposure. For microbiological agents, exposure assessments might be based on the potential extent of food contamination by a particular agent or its toxins, and on dietary information. Exposure assessment should specify the unit of food that is of interest, i.e., the portion size in most/all cases of acute illness.

Factors that must be considered for exposure assessment include the frequency of contamination of foods by the pathogenic agent and its level in those foods over time. For example, these factors are influenced by the characteristics of the pathogenic agent, the microbiological ecology of the food, the initial contamination of the raw material including considerations of regional differences and seasonality of production, the level of sanitation and process controls, the methods of processing, packaging, distribution and storage of the foods, as well as any preparation steps such as cooking and holding.

Another factor that must be considered in the assessment is patterns of consumption. This relates to socio-economic and cultural backgrounds, ethnicity, seasonality, age differences, regional differences, and consumer preferences and behaviour. Other factors to be considered include: the role of the food handler as a source of contamination, the amount of hand contact with the product, and the potential impact of abusive environmental time/temperature relationships.

Microbial pathogen levels can be dynamic and while they may be kept low, for example, by proper time/temperature controls during food processing, they can substantially increase with abuse conditions. Therefore, the exposure assessment should describe the pathway from production to consumption. Scenarios can be constructed to predict the range of possible exposures.

The scenarios might reflect effects of processing, such as hygienic design, cleaning and disinfection, as well as the time/temperature and other conditions of the food history, food handling and consumption patterns, regulatory controls, and surveillance systems.

Exposure assessment estimates the level, within various levels of uncertainty, of microbiological pathogens or microbiological toxins, and the likelihood of their occurrence in foods at the time of consumption. Qualitatively foods can be categorised according to the likelihood that the foodstuff will or will not be contaminated at its source; whether or not the food can support the growth of the pathogen of concern; whether there is substantial potential for abusive handling of the food; or whether the food will be subjected to a heat process.

The presence, growth, survival, or death of microorganisms, including pathogens in foods, are

influenced by processing and packaging, the storage environment, including the temperature of storage, the relative humidity of the environment, and the gaseous composition of the atmosphere. Other relevant factors include pH, moisture content or water activity (a_w), nutrient content, the presence of antimicrobial substances, and competing microflora. Predictive microbiology can be a useful tool in an exposure assessment.

Hazard Characterisation

This step provides a qualitative or quantitative description of the severity and duration of adverse effects that may result from the ingestion of a microorganism or its toxin in food. A dose-response assessment should be performed if the data are obtainable. There are several important factors that need to be considered in hazard characterisation. These are related to both the microorganism, and the human host.

In relation to the microorganism the following are important: microorganisms are capable of replicating; the virulence and infectivity of microorganisms can change depending on their interaction with the host and the environment; genetic material can be transferred between microorganisms leading to the transfer of characteristics such as antibiotic resistance and virulence factors; microorganisms can be spread through secondary and tertiary transmission; the onset of clinical symptoms can be substantially delayed following exposure; microorganisms can persist in certain individuals leading to continued excretion of the microorganism and continued risk of spread of infection; low doses of some microorganisms can in some cases cause a severe effect; and the attributes of a food that may alter the microbial pathogenicity, e.g., High fat content of a food vehicle.

In relation to the host the following may be important: genetic factors such as human leucocyte antigen (HLA) type; increased susceptibility due to breakdowns of physiological barriers; individual host susceptibility characteristics such as age, pregnancy, nutrition, health and medication status, concurrent infections, immune status and previous exposure history; population characteristics such as population immunity, access to and use of medical care, and persistence of the organism in the population.

A desirable feature of hazard characterisation is ideally establishing a dose-response relationship. When establishing a dose-response relationship, the different end points, such as infection or illness, should be taken into consideration. In the absence of a known dose-response relationship, risk assessment tools such as expert elicitations could be used to consider various factors, such as infectivity, necessary to describe hazard characterisations. Additionally, experts may be able to devise ranking systems so that they can be used to characterise severity and/or duration of disease.

Risk Characterisation

Risk characterisation represents the integration of the hazard identification, hazard characterisation, and exposure assessment determinations to obtain a risk estimate; providing a qualitative or quantitative estimate of the likelihood and severity of the adverse effects which could occur in a given population, including a description of the uncertainties associated with these estimates. These estimates can be assessed by comparison with independent epidemiological data that relate hazards to disease prevalence.

Risk characterisation brings together all of the qualitative or quantitative information of the previous

steps to provide a soundly based estimate of risk for a given population. Risk characterisation depends on available data and expert judgements. The weight of evidence integrating quantitative and qualitative data may permit only a qualitative estimate of risk. The degree of confidence in the final estimation of risk will depend on the variability, uncertainty, and assumptions identified in all previous steps.

Differentiation of uncertainty and variability is important in subsequent selections of risk management options. Uncertainty is associated with the data themselves, and with the choice of model. Data uncertainties include those that might arise in the evaluation and extrapolation of information obtained from epidemiological, microbiological, and laboratory animal studies.

Uncertainties arise whenever attempts are made to use data concerning the occurrence of certain phenomena obtained under one set of conditions to make estimations or predictions about phenomena likely to occur under other sets of conditions for which data are not available. Biological variation includes the differences in virulence that exist in microbiological populations and variability in susceptibility within the human population and particular subpopulations. It is important to demonstrate the influence of the estimates and assumptions used in risk assessment; for quantitative risk assessment this can be done using sensitivity and uncertainty analyses.

The risk assessment should be fully and systematically documented and communicated to the risk manager. Understanding any limitations that influenced a risk assessment is essential for transparency of the process that is important in decision making. For example, expert judgements should be identified and their rationale explained.

To ensure a transparent risk assessment a formal record, including a summary, should be prepared and made available to interested independent parties so that other risk assessors can repeat and critique the work. The formal record and summary should indicate any constraints, uncertainties, and assumptions and their impact on the risk assessment.

Reassessment

Surveillance programmes can provide an ongoing opportunity to reassess the public health risks associated with pathogens in foods as new relevant information and data become available. Microbiological risk assessors may have the opportunity to compare the predicted risk estimate from microbiological risk assessment models with reported human illness data for the purpose of gauging the reliability of the predicted estimate. This comparison emphasises the iterative nature of modelling. When new data become available, a microbiological risk assessment may need to be revisited.

Draft Guidelines for Incorporating Microbiological Risk Assessment in the Development of Food Safety Standards

The introduction, in recent years, of preventive strategies (e.g., the application of HACCP) and risk assessment concepts are leading to fundamental changes in the approach to food safety. Governments in a number of countries are now undertaking quantitative risk assessments for specific microbiological hazards in the food supply, with the intention that the outputs of these risk assessments will be used in the development of food safety measures at the national level. Internationally, FAO and WHO have embarked on a series of Joint Expert Meetings on Microbiological Risk Assessment (JEMRA) that represents an extensive and on-going scientific commitment to risk assessment. The Codex Committee on Food Hygiene (CCFH) is currently considering the preliminary results of the risk assessments of *Salmonella* spp. in eggs and broiler chickens and *Listeria monocytogenes* in ready-to-eat (RTE) foods, and quantitative risk assessments on *Campylobacter* spp. in poultry and *Vibrio* spp. in seafood are underway to

provide the committee with the scientific advice it has requested.

Microbiological risk assessment (MRA) is resource-intensive in terms of scientific input and time, and effective incorporation of MRA in the development of food safety standards, guidelines and related texts requires systematic and transparent application of a framework for managing food-borne hazards. The provisions and obligations of the World Trade Organisation's (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) that apply to safety measures for foods in trade are an additional incentive for MRA to be used in a systematic and transparent manner.

Generic frameworks for managing food-borne risks have recently been described by FAO/WHO, Codex and national governments. The four components of such frameworks can be summarised as follows:

Preliminary risk management activities comprise the initial process. It includes the establishment of a risk profile to facilitate consideration of the issue within a particular context, and provides as much information as possible to guide further action. As a result of this process, the risk manager may commission a risk assessment as an independent scientific process to inform decision-making.

Evaluation of risk management options is the weighing of available options for managing a food safety issue in light of scientific information on risks and other factors, and may include reaching a decision on an appropriate level of consumer protection. Optimisation of food control measures in terms of their efficiency, effectiveness, technological feasibility and practicality at selected points throughout the food chain is an important

goal. A cost-benefit analysis could be performed at this stage.

Implementation of the risk management decision will usually involve regulatory food safety measures, which may include the use of HACCP. Flexibility in the choice of individual measures applied by industry is a desirable element, as long as the overall programme can be objectively shown to achieve the stated goals. On-going verification of the application of food safety measures is essential.

Monitoring and review is the gathering and analysing of data so as to give an overview of food safety and consumer health. Monitoring of contaminants in food and food-borne disease surveillance should identify new food safety problems as they emerge. Where there is evidence that required public health goals are not being achieved, redesign of food safety measures will be needed.

This document utilises a generic framework for managing risks to provide guidelines for systematically incorporating MRA in the development of food safety standards, guidelines and related texts. These guidelines jointly reflect current constraints and future expectations in respect of MRA. The guidelines can be applied by Codex and national governments as appropriate.

Preliminary Risk Management Activities

Preliminary risk management activities that are necessary for application of an overall framework for managing food-borne risks to human health include a number of separate components. Figure 1 illustrates the decisions that have to be made during preliminary risk management activities, and how they relate to MRA.

Use of MRA as the scientific basis for food safety risk management is the focus of this document. However, it

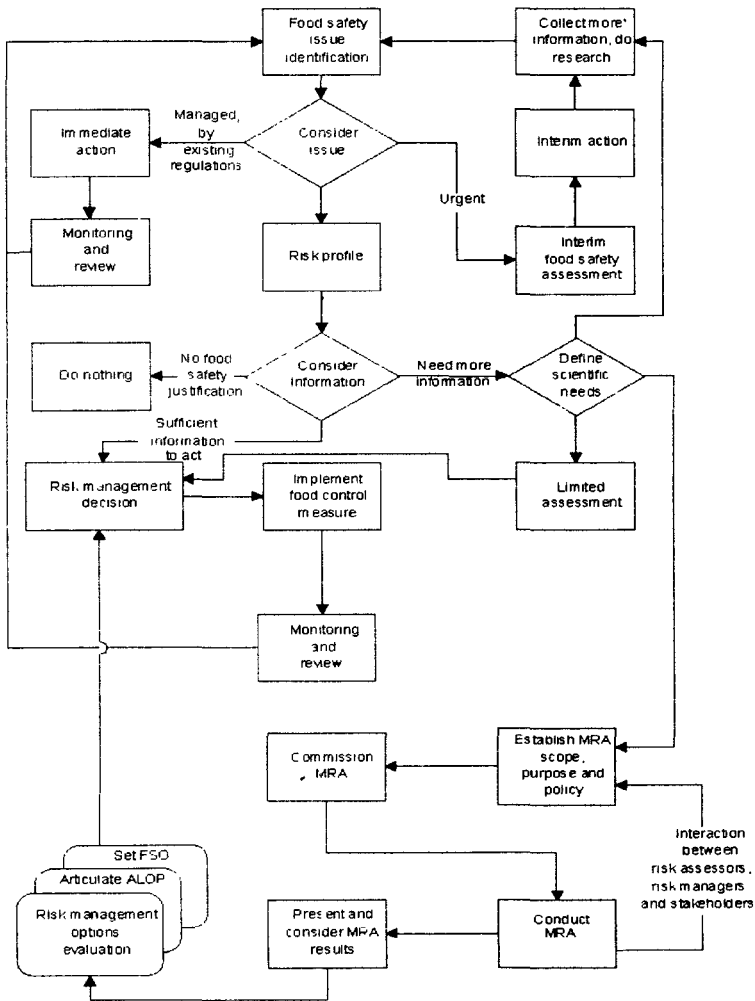


Figure 1. Decision chart for preliminary risk management activities in relation to an overall framework for managing food-borne risks to human health

must be recognised that many food safety issues can be successfully managed without commissioning an MRA e.g. there is a long history of using Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), and HACCP to prevent, minimise or eliminate food-borne risks in the absence of MRA. Consequently, this document also provides guidance on deciding when a MRA may be useful and when it is probably not advisable.

Communication and interaction of risk managers with various parties may occur at several points during the preliminary risk management process. For example, there may be interaction with other parties to gather information needed to complete the risk profile; to help refine/correct/expand the risk profile; to help determine the feasibility and acceptability of possible responses to the issue; and to communicate the decision taken as a result of the risk profile. To help address the need for more interaction between risk assessors and risk managers at the international level, ad hoc drafting groups have been established by CCFH to "manage" MRAs and associated activities between annual meetings of that Codex committee. Each drafting group has temporary authority to communicate with risk assessors working on specific MRAs i.e. *Campylobacter* spp. in broilers, *Listeria* spp. in ready-to-eat-foods and *Vibrio* spp. in seafood.

Identification of a Food Safety Issue

The food safety issue that is the entry point for preliminary risk management activities can be formulated in many ways: broadly or specifically, affecting one commodity or many commodities, involving one pathogen or multiple pathogens, involving an emerging

problem or an endemic problem. Food safety issues include:

- Setting priorities amongst different food safety problems e.g., conduct a risk ranking;
- Addressing a specific public health food safety problem e.g., *Salmonella* Enteritidis in eggs;
- Justifying or evaluating a new or alternative measure, technology, or inspection system;
- Making an equivalency determination.

The issue may come to the attention of the risk manager from a variety of sources e.g. disease surveillance, enquiry from a trading partner, consumer concerns or industry information. The risk manager needs to decide whether to pursue the issue or not.

Within Codex, the issue may be raised by a Member government or Observer organisation. Codex may request a member country or group of countries to prepare a draft risk profile on a particular issue, which would then be considered as a potential topic of future MRA work.

Initiating Immediate Interim Decisions

Some food safety issues will require that an immediate, interim decision be taken without further scientific consideration. The nature of the actions taken will reflect the character of the issue that generates that action. Some examples are:

- Application of a set of predetermined criteria and procedures following arrival at a port of entry of a product of ambiguous food safety status;
- Soliciting expert opinion when a potential health risk is brought to the attention of the risk manager

by independent scientists or other members of the public;

- Initiating immediate action to determine the nature and scope of a food safety issue following the first occurrence of illness from a new or emerging pathogen.

In each case where immediate action is taken, it is essential that adequate communication occurs between managers and interested and affected parties. Actions should be followed by the collection of additional information that may inform and modify the risk management response. It is important to recognise that the resulting actions are temporary and will likely need to be replaced with more informed decisions.

One technique for supporting immediate, interim actions is the construction of interim food safety assessments. Such assessments contain elements of MRA. They depend on readily accessible information, realistic scenarios, and, where available and applicable, modules from previously constructed MRAs, e.g., the farm module from the MRA of *Salmonella* in poultry could be used to begin work on *Campylobacter* spp in poultry.

Risk Profile

Notwithstanding any interim action as an immediate response to a food safety issue, the purpose of a risk profile is to enable a decision to be made on what will be done next and whether resources should be allocated to a more detailed scientific assessment. A risk profile comprises a systematic collection of information needed to make a decision, and is the responsibility of the risk manager. At the international level, Codex would usually allocate the preparation of a risk profile to a country or group of countries.

The individual or group preparing the profile needs to determine at the outset what information is needed, how, from where and from whom they will obtain it. A key first step in preparing a risk profile should be to determine available resources e.g. human, financial, time. Typically the risk profile would be a short document completed in a timely manner, depending on the time available to the risk manager and the nature of the issue.

The scope and detail of a risk profile, and the extent of interaction with other parties required to prepare it, depends on the food safety issue under consideration and the information needs of the risk manager. The extent of interaction with risk assessors, scientists, consumers, industry, and other interested parties depends on the time available, information needs, complexity of the food safety issue, and the likely impact of risk management decisions on different parties. Interaction with risk assessors to gain clarity on the specific questions that will need to be addressed by risk managers is particularly important, and specific scientific inputs may be sought.

A risk profile may include the following descriptive elements, using information that is relevant and readily accessible:

- A concise description of the food safety issue;
- Information about the hazard e.g. general description, extent of knowledge on the relationship between hazard and adverse health effects;
- Any unique characteristics of the pathogen/human relationship;
- Information about exposure to the hazard e.g. routes of exposure (food, water, direct contact with

animals, etc.), prevalence, characteristics of the hazard, levels of hazard throughout the food chain, possible control measures and their feasibility and practicality;

- Information on the adverse health effects on humans e.g. types and severity of adverse health effects, subsets of populations at increased risk (differing susceptibility, food intake, socio-economic status, geographical location), prevalence and incidence data from public health surveillance;
- Other information relevant to risk management decision-making e.g. adequacy of the available data, perceptions of the food safety issue by interested parties, practical considerations (economic, technical, political, legal), possible actions and expected consequences (public trust in the decision-making process, distribution of risks and benefits);
- Proposals for risk management questions to be answered by risk assessors.

Initial Risk Management Decisions

Consideration of the information generated in the risk profile by the risk manager may result in a range of initial decisions (Figure 1). Where risk management action is needed, the risk manager may commission a MRA to provide appropriate scientific information on risks. In other cases, a MRA may not be needed or may not be possible, and a less extensive assessment can be more appropriate. Other options are to gather more information to better inform preliminary risk management activities e.g. establish data collection systems, design and conduct research to further investigate an issue. A possible

consequence of a decision to gather more information is a new risk profile. In other cases, the risk profile may provide sufficient information for risk managers to directly select and implement risk management options (Figure 1). In cases where consideration of the risk profile leads to the conclusion that the issue does not justify further action, that decision and the rationale and supporting information should still be communicated to interested parties.

The above decision options are also available to Codex at the international level. A decision to request advice or information may be directed to a number of sources e.g. to FAO and WHO (JEMRA) or member governments. Where a risk profile contains sufficient information, Codex may immediately initiate work on appropriate food safety standards.

In some circumstances, establishing the scope of a prospective MRA may reveal that there is insufficient information available to commission the MRA. In such cases, a decision to proceed with evaluation of risk management options will be based on a limited assessment (Figure 1) e.g. in one country, there was insufficient dose-response information on *Vibrio parahaemolyticus* in seafood to permit a MRA, and, therefore, generic control measures based on GHP and HACCP were implemented. In such cases, further action would include collection of more detailed information so as to revisit application of the generic framework for managing food-borne risks (Figure 1).

Defining Purpose and Scope of the MRA

The purpose of a MRA is to provide an objective interpretation of relevant scientific knowledge to help the risk manager make an informed decision, especially when

other means of assimilating information for the purposes of risk management are not adequate. The purpose and scope of the MRA should be clearly defined before beginning the work, and this is facilitated by discussions between risk managers, risk assessors, and other relevant parties e.g. food safety scientists, industry and consumers. The risk profile, together with other documentation on the particular food safety issue, provides the basis for such discussions.

An important first step is to clarify risk management goals, and formulate the specific questions that should be answered by the MRA. An example of a risk management issue is "How should the risk of contracting salmonellosis from egg-containing foods served in restaurants be managed?" The risk assessor should be made fully aware of the nature of the risk management question, but not be required to provide the answer to that question.

Based on the above example, the risk manager might pose the following questions to the risk assessor:

- "What is the exposure to *Salmonella* from consumption of egg-containing foods in restaurants?"
- "What is the likelihood of the general population (or a sensitive subset of the population) contracting salmonellosis from eating egg-containing foods in restaurants?"
- "How much is the risk reduced if 'use by dates' are required on all fresh eggs?"

Questions posed by the risk manager for individual MRAs will depend on the particular risk management goals, the hazard involved, the food matrix, the exposure pathway, and the intended use of the information

generated from the MRA. Where the MRA is to be used to inform the development of food safety measures, the specific type of measure needs to be identified. These measures include standards that contain quantitative elements, guidelines that contain qualitative elements e.g. codes of practice, and more general texts e.g. general recommendations on design of food safety programmes. In other situations, the questions posed by risk managers may be more general in nature e.g. prioritisation of broad food safety policies, or prioritisation of foods or food commodity groups for more intensive food safety control.

Defining the scope of the MRA will determine the degree of detail required. In the ideal situation, the exposure pathway developed in the MRA will cover the entire production-to-consumption continuum, and the scope will detail the specific consumer population(s) of concern, the adverse health end-point(s) that are of interest, and other aspects that will guide data collection, modelling, analysis, and presentation of results. Properly defining the scope will also provide insights as to the timeframe and resources that will be needed for the MRA.

Establishment of MRA Policy

Establishment of MRA policy depends on adequate definition of the scope and purpose of the MRA, and consists of documented guidelines for judgements or policy choices.

Establishing MRA policy helps ensure that the MRA is systematic, complete and transparent. It also protects the scientific integrity of the MRA process. It is the responsibility of risk managers, but should be decided upon in co-operation with risk assessors and other interested parties, preferably before the MRA commences.

During the conduct of the MRA, circumstances often arise that require new assumptions and possibly revision of predetermined guidelines. It is essential that all aspects of MRA are fully documented.

Effective establishment and implementation of MRA policy will require considerable interaction between risk assessors and risk managers. Some circumstances may require more frequent interaction than others e.g. in cases of highly uncertain information for a range of MRA data inputs. In some cases, interactions may benefit from involvement of a risk communication facilitator, and there may be a need for process review to ensure interactions are timely and appropriate. Questions regarding involvement of other interested parties may also be regarded as part of MRA policy, and this will be influenced by the nature of the food safety issue, resources available, timeframes and the need for confidentiality. Further issues include guidelines for peer review and at what stages in the process a review should be undertaken.

Generic aspects of MRA policy

Risk management authorities and other organisations may have generic policies for the conduct of some aspects of MRA e.g. FAO/WHO generally require that MRA activities include considerations specifically relevant for developing countries. At the national level, generic MRA policy may require certain choices that are inherently cautious when data gaps exist. Further, MRA may be required to always include risk estimates for the most susceptible or otherwise defined sub-populations e.g. children. A standing requirement for multi-disciplinary MRA teams may be considered as a generic aspect of MRA policy.

Specific aspects of MRA policy

For individual MRAs, any management guidelines that will impact on scope, data considerations, analysis, interpretation and presentation of MRA results should be explicitly recognised and documented. Such guidelines may also influence the resources that will be required e.g., the time and expertise to conduct a probabilistic production-to-consumption MRA for *Salmonella* spp. in raw poultry is significantly more resource-intensive than a deterministic estimation of population risk, based on levels of *Salmonella* contamination on poultry at retail.

Although risk managers have the responsibility for establishing key guidelines related to scientific value judgements made by risk assessors, the latter have the responsibility for depicting the impact of these guidelines on the outputs of the MRA. Examples of issue-specific MRA policy include:

- Guidelines for key scientific judgements when there is a high degree of uncertainty in existing data, or data are lacking;
- Adverse health parameters for presenting risks to human health e.g. disability-adjusted life years;
- Sources of data to be considered, and any temporal, geographical, or other restrictions that may be put in place.

Commissioning of the MRA

The risk manager is responsible for assembling the MRA team that will carry out the work. Often, the greatest benefits are realised when a multi-disciplinary team is assembled. This is particularly applicable if the scope of the MRA includes modelling of the production-to-

consumption food chain. In any case, MRAs typically must integrate different kinds of information from diverse fields of study e.g. microbiology, microbial ecology, food technology, food hygiene, epidemiology and public health. Access to technical experts in the relevant sciences is needed, in addition to risk modelling expertise.

The mandate given by risk managers to risk assessors should be as clear as possible, and documented as a "contract" or terms of reference for the conduct of the MRA. The roles and responsibilities of both risk managers and risk assessors should be clearly agreed upon before initiation of the MRA. In particular, the risk assessors should explain the potential impact of key assumptions made on the outcomes of the MRA.

Risk estimates can be presented in several ways e.g., risk per serving, risk per year, risk per lifetime, relative risks. Thus a description of the required form of the risk estimate should be determined during the commissioning of a MRA. Aggregation of human health measures to create health-related quality of life measures, such as disability-adjusted life-years (DALYs), is one way of standardising the output of a risk assessment.

It may be helpful, and indeed necessary for complex MRAs, to identify a project manager whose job it is to co-ordinate the work, translate the technical information into terms that are readily understood, present interim findings to managers, and facilitate feedback from managers to assessors. It may also be advantageous to assign a risk communicator to facilitate interactions with other interested parties, as risk assessors and risk managers may not be sufficiently aware of the importance of, or have the skills and resources necessary to implement a comprehensive risk communication

strategy. Information that may be documented in the commissioning of a MRA includes:

- Description of the specific risk management issue;
- Scope and purpose of the MRA;
- The MRA question(s);
- The risk profile;
- The type of MRA to be conducted, expertise needed, and resources allocated;
- How the outputs of the MRA will be used by risk managers;
- Timelines, including those for milestone reporting, manager-assessor meetings, stakeholder fora, completion targets;
- Criteria to validate the risk model and outcomes, and assess “reasonableness”;
- Criteria to determine scientific and technical adequacy of the MRA;
- Analysis of any future data needs.

Risk managers should be aware of a possible conflict of interest between the desired time-frame for results to be available versus the time needed to properly conduct a MRA.

Interaction during the Conduct of the MRA

Functional separation between risk managers and risk assessors is an established principle in the application of a generic framework for managing risks to human health. However, effective interaction between these groups and, as appropriate, other interested parties, during the conduct of a MRA is essential. Scientific findings may

lead to revising and clarifying the risk management questions, or altering the scope, focus and expected outputs of the MRA. In addition, it is not always possible prior to conducting the MRA to anticipate all the points where MRA policy decisions are needed, nor to anticipate all data needs. Frequent meetings of relevant interested parties will help to ensure that important issues are fully addressed, and will enhance understanding of the analytical process.

Risk assessors have a responsibility to communicate regularly with risk managers on the impact that assumptions, data gaps, and choices about data selection, interpretation and modelling will have on the conduct and outputs of the MRA. Risk managers have a responsibility to request sufficient information from risk assessors so that they understand how MRA policy impacts on the MRA, and consequently take that into account in subsequent decision-making.

Objective criteria should be established to judge when the MRA work has achieved the targets set out in the commissioning document. Biases and personal preferences should not influence application of such criteria. It is recognised that new scientific data are constantly becoming available, but the value of incorporating more data must be weighed against all of the terms of reference for the work already commissioned. For this purpose, peer review by individuals with different perspectives and expertise is valuable. Analytical aspects of the MRA should be peer reviewed by independent MRA experts, while other scientific inputs should be peer reviewed by experts in relevant fields.

Presentation of Results from MRA

Risk assessors must strive to ensure that the logic,

outcome, significance, and limitations of the work are clearly understood by managers and others, including those who have a specific role in risk communication with interested parties. The risk managers have the overall responsibility for ensuring that the results of the MRA are communicated appropriately to other relevant parties.

Risk Estimates

The outputs of the MRA should be presented by risk assessors in a manner that can be properly utilised by risk managers in the evaluation of different risk management options. Although the primary task may be to provide a quantitative description of the risk, assessors should enhance the value of the estimate by providing additional narrative e.g. on sources of uncertainty and biological variation, the quality of data sets used, and assumptions made. Furthermore, variability and uncertainty should be independently characterised and properly presented in the output of the MRA.

In most cases, a risk estimate is arrived at in the context of existing food safety measures. Preliminary evaluation of the risk assessment results may generate a request from risk managers for a modified risk estimate under circumstances of different food safety measures. Thus, MRA models have specific utility in exploring the effect of alternative food safety measures, at different steps in the food chain, on the risk estimate.

Format of reports

Generally, the presentation of MRAs should be conveyed in at least two different formats: a technical report for scientists, managers with specific technical expertise and interested members of the public, and an interpretative

summary to assist risk managers and a broader, less-technical audience to understand the risk assessment.

The technical MRA report will typically be a lengthy and detailed document that should report all information needed to reproduce the MRA. Clarity can be achieved by defining technical terms, minimising the use of jargon, and including well-designed tables and graphs. It should be self-explanatory, written in plain language and provide:

- All data, inferences, assumptions, calculations, technical descriptions and model parameters with assigned values and/or distributions. These should be presented in summary tables or appendices that allow readers to follow the logic of the MRA in a transparent manner;
- All relevant information on data gaps, uncertainty and variability in the data, acknowledgement of assumptions made, and their influence on MRA outcomes;
- A description of criteria used to assign categories if a scalar or ranking system is used to characterise MRA parameters;
- A risk characterisation that clearly presents the outcome of the MRA process and describes important factors that may alter the risk estimate e.g. new knowledge, different assumptions, changes in exposure pathways;
- Description of analytical methods that may have been applied to measure the potential importance of different model inputs as contributors to variation in risk estimates, and the results;

- Comparison of the results of exposure assessment and hazard characterisation against any available data that were not included in the model e.g. validation of model predictions against independent epidemiological or experimental data;
- A discussion of MRA outputs presented in a separate section of the report. This section may include the views of the risk assessors on the feasibility and effectiveness of specific hazard control measures, and other suggestions on the practical use of the MRA. By separating such views from the actual risk characterisation, the science-based analyses are separate and explicit.

The interpretative summary is a short document that should explain the purpose of the work, how the assessment was conducted, the results and conclusions, and the importance of the conclusions in a way that non-scientists can understand. Flow charts, scenario trees, influence diagrams, and other means of graphically representing the process and the results are useful to readily convey information and to facilitate the reader's comprehension.

Other Reporting Strategies

Other strategies for communicating MRA results include having the risk assessors provide a draft report, and then assigning a team of scientific writers and senior managers to prepare a final document that provides the risk managers with the information they need to make informed decisions. Communications for broader audiences may include oral presentations and public meetings. The use of knowledgeable individuals with good communication skills is essential to achieving the risk managers' communication goals.

Consideration of Results of MRA

When presented with the results of the MRA, the risk managers should ensure that the information provided is sufficient for decision-making as specified in the purpose and scope of the MRA. They should fully understand the distribution of risk as presented in the MRA and confirm that the questions posed in the commissioning document have been appropriately addressed.

To achieve these goals, the risk assessors should brief the risk managers accordingly. They should provide an understanding of how the MRA was conducted, and describe the specific implications and limitations, including their impact on the resulting risk estimate, that are associated with:

- Analytical approaches employed e.g. use of distributions for inputs and outputs rather than reliance on deterministic values, influence of including extremes of distributions;
- Parameters used to characterise the risk estimate e.g. mean, median;
- Impact on risk estimates of key data gaps, and sources of uncertainty and variability;
- How the risk estimate would differ if alternative inputs and assumptions were used;
- Any constraints on the conduct of the MRA in terms of influencing the outputs;
- Use of specific tools e.g. rank correlation's are a starting point in considering the importance of specific information-gathering needs, and can provide an initial screening of the importance and effectiveness of various potential control points in the hazard exposure pathway;

- Comparison of the risk estimate with available epidemiological data.

Iterative communication between risk managers and risk assessors during the MRA work should have prevented any unexpected outcomes, and provided for alternative strategies where outputs documented in the commissioning process could not be delivered.

If specific questions could not be answered, the risk manager should be able to understand the reason. Furthermore, the risk manager should be presented with recommendations as to how these questions could be answered in a future iteration of the MRA.

The risk manager should then decide whether the MRA is adequate to proceed further in evaluating risk management options, or whether there are elements of the MRA that need further work.

Evaluating Risk Management Options

It is fully recognised that the steps used by competent authorities when responding to a food safety issue vary according to the particular circumstances (Figure 1). Flexibility in risk management responses is necessary because the factors surrounding food safety issues are often complex, unpredictable and may present new challenges in terms of protecting consumer health. However, the focus of the current guidelines is the evaluation of risk management options on the basis of a MRA being available. Further, guidelines on the establishment of an appropriate level of protection as articulated in the WTO SPS Agreement is a key theme.

Identification and Selection of Risk Management Options

During the development of an MRA, a number of

pathogen-food commodity-specific risk management options may have been identified. In some situations, the purpose of the MRA will be to illuminate the impact of risk reduction interventions based on an evaluation of relative risks e.g. comparing the impacts of different control options against an initial baseline estimate of risk. A focus on comparative risk reduces the need to establish a quantitative estimate of risk for each food control strategy.

Evaluation of risk management options will likely be an iterative process. The risk managers should know the degree of public health protection they are aiming to achieve. A number of different food safety measures, either alone or in combination, can be considered. It is likely that the risk assessors will have examined the impacts of different control options and approaches on food-borne risks, providing the risk managers with data that allows them to more objectively reach decisions on the most appropriate food safety measures. An iterative process continues until one or more risk management options that can achieve the desired level of consumer protection are identified. These options could include development of regulatory standards. Possible risk management options include:

- Avoid risks by banning the food, or limit sales of food that have a history of contamination or toxicity under certain conditions e.g. raw molluscan shellfish harvested under certain conditions;
- Reducing exposure e.g. informing susceptible consumer groups not to eat specific foods;
- Education of consumers e.g. labelling products to warn/inform susceptible consumers groups;

- Control initial levels of hazards e.g. by selecting ingredients that have been pasteurised, using microbiological criteria to reject unacceptable ingredients or products;
- Prevent an increase in the levels of hazards e.g. prevent contamination by appropriate food controls at different points in the food chain, and prevent growth of pathogens by temperature control, pH, aW, preservatives;
- Reduce levels of hazards e.g. destroy pathogens/parasites by freezing, disinfection, pasteurisation, irradiation;
- Remove pathogens e.g., washing, ultra-filtration, centrifuging;
- Do nothing, as appropriate to the food safety issue under consideration and the output of the MRA.

Evaluation of risk management options should involve a comparison of their inherent advantages and disadvantages together with their impact on risks. Relevant considerations include: acceptability of the technology or the resulting food product by industry and/or consumers, cost effectiveness, technological feasibility, expected level of compliance with control measures, options for monitoring and review, and the possibility of new risks arising from the options selected. Where food safety objectives (FSOs) are established, identification of a range of possible risk management options will offer industry the greatest flexibility in implementation of food control measures.

If a decision to mandate specific risk management options is taken, this may achieve a short-term food safety goal but it may not allow manufacturers to be

innovative in developing new approaches to meeting a FSO. It also reflects a "command and control" regulatory approach that may deny contemporary risk-based approaches to food safety.

In evaluating risk management options, all relevant data, knowledge and information pertinent to the decision are often dispersed among various interested parties. This expertise should be brought together in the most effective manner possible. This may include for example:

- Knowledge on capabilities and performance of operations/industries at all steps in the food chain;
- Likely abuse of the food e.g. during retail, "food service", handling by consumers;
- Quality and safety of existing and "substitute" food products;
- Knowledge of alternative technologies;
- Knowledge on consumer preferences, values, dietary habits, and other information relevant to risk management.

A key question that should be asked during the evaluation of risk management options concerns who judges an option to be optimal and according to what criteria e.g. steam surface pasteurisation of citrus fruit to remove pathogens may provide the same reduction in risks as washing by hand in an appropriate sanitising solution. Where labour costs are high, the former measure may be the most optimal. A cost-benefit analysis could be performed.

The outcome of a national MRA may be an absolute or relative estimate of risk for a generic category of food,

and all interested parties will be involved in establishing an ALOP. In contrast, a food industry MRA is likely to consider only relative estimates of risk associated with their own food product. Those estimates will be focused on exposure levels known to be "safe". In this context, exposure assessment in MRA offers the food industry a more sophisticated means to compare margins of safety for different products and to design optimal food controls. Furthermore, industry may utilise national and international MRAs to reassess and review their existing food production practices and to develop additional food controls such as instructions for correct handling, preparation and use.

Steps taken in Evaluating Risk Management Options

The risk manager will have to carry out a step-wise process in evaluation of risk management options. In some circumstances, reaching a decision on an ALOP will be a prerequisite to developing specific food safety measures. A national competent authority will include many factors in making such decisions e.g. level of risk for the consumer population associated with particular hazards, and prioritisation of such risks in terms of prevalence, severity and/or economic burden on society. Risk managers should also consider whether establishing an ALOP for a specific disease would enhance their food safety policies and strategies for food control. In some international trade situations, an exporting country may exercise the provisions and obligations of the WTO SPS Agreement and request that an importing country describe the ALOP associated with specified import controls.

Establishing an ALOP is the responsibility of the risk manager but societal values are a key input. Extensive

and iterative public consultation and communication will be needed so as to provide appropriate transparency and obtain full stakeholder commitment to the process.

Steps in evaluating risk management options at the national level

Once the risk managers have received and accepted an MRA, it becomes their responsibility. An action plan should be established to:

- consider any immediate risk management action to be taken in response to the outcome of the MRA,
- brief relevant interested parties on the MRA (e.g. consumers, industry),
- solicit public comment, and
- evaluate risk management options.

The steps involved are as follows:

- A team who will describe the MRA and the implications of the findings should be assembled and briefed. The advice of professional communicators may be sought. Throughout the evaluation of risk management options they may help to assure that information provided during iterative interactions with all interested parties is scientifically accurate and in a form that can be readily understood;
- If necessary, the risk manager will establish a working group to carry out specified aspects of evaluation of risk management options. This may include developing parameters related to setting of an ALOP or a FSO. Personnel from the MRA team should be included so as to provide full and

detailed knowledge of the outputs of the MRA work and their implications for risk management;

- When the working group has identified the available risk management options and their consequences, in terms of level of consumer protection and the practicality and feasibility of the options, they have to be communicated to senior risk managers. Individuals have to be empowered to present the risk management options of choice, and public consultation used to initiate the communication process with all interested parties;
- Public consultation and interaction may comprise: workshops, public meetings, informal meetings, technical fora, formal register notices, and written and electronic communications. Interested parties include: public health and medical sectors; food industry e.g. primary producers, food processors, catering, distribution and retailers; trade associations; consumer organisations; academia, scientific advisory commissions and other institutional bodies; other competent authorities etc.. During the iterative consultative process, the working group may identify that additional information is needed, e.g. risk assessors may be asked to quantify the impact of different food safety control scenarios on the level of consumer protection provided;
- The senior risk managers will finally decide on the appropriate risk management options and communicate this decision to all relevant parties. An inclusive and transparent risk communication process will assist in securing a broad consensus on the options chosen.

Evaluating risk management options at the international level

Codex can be considered as the risk manager in relation to food safety at the international level. Specific considerations for the evaluation of risk management options at this level include:

- Briefing of risk managers, for example via informal presentations to national delegates ahead of a formal Codex Commission or committee session, using presenters who were part of the MRA team;
- Establishing mechanisms to facilitate more frequent interaction between the risk managers and the risk assessors to discuss the evolution of the work and the implications and utility of the outputs of the MRA;
- Public consultation, for example via formal presentations to international meetings, issuing of a circular letter to Codex contact points, or posting the information on a public web-site and following up by appropriate mechanisms at the national level;
- Installation of a mechanism (e.g. working group) to facilitate the use of MRA in the elaboration of a standard, guideline or related text as part of the Codex procedure.

Using MRA in Evaluation of Risk Management Options

In the simplest situation, the risk manager may be uncertain about the extent of food-borne risks due to a particular pathogen and the predominant specific food vehicles that are responsible. A MRA can be used to estimate specific risks and indicate how a particular industry or practice is contributing to that risk. In other situations, risk managers may define an ALOP in terms of a desired reduction in the current level of risk within a

given period of time. A MRA can then be used to examine potential risk management options that could be used to achieve that goal.

MRA is a particularly useful tool when the risk management issue is complex. A risk characterisation should provide insights about the nature of the risk, even when this is not captured by a qualitative or quantitative estimate of risk. The risk assessor may also be able to use the risk model to run a number of simulations to compare the likely effectiveness of alternative methods of risk reduction enabling the risk manager to consider and compare risk management options. Figure 2 illustrates the output produced from a comparison of different exposure scenarios.

Given different food production practices and technologies, a MRA can be used to judge equivalence in terms of public health outcomes e.g. heat pasteurisation versus high pressure "pasteurisation". The choice of adopting alternative technologies will depend upon factors such as effectiveness, cost and acceptability.

Approaches for Articulating an Appropriate Level of Protection (ALOP)

In the context of food safety, an ALOP is a statement of the degree of public health protection that is to be achieved by the food safety systems implemented within a country. Typically, an ALOP would be articulated as a statement related to the disease burden associated with a particular hazard/food combination and its consumption within a country, and is often framed within a context for continual improvement in relation to disease reduction.

For example, if a particular country has a reported incidence of salmonellosis attributable to poultry of 10 cases per 100 000 population and wants to implement a

program that reduces that incidence, there are two possible approaches to converting this goal into an active risk management program. The first is an articulation of a specific public health goal. For example, the country could set a goal of reducing the reported incidence of salmonellosis attributable to poultry to 5 cases per 100 000 population. The underlying assumption in such a public health goal is that there are practical means by which this can be achieved. The alternative approach is to evaluate the performance of the risk management options currently available, and to select the ALOP based on the capabilities of one or more of the options. This is often referred to as an "as-low-as-reasonably-achievable" (ALARA) approach.

Both approaches have strengths and limitations and have been used in various countries to articulate food safety public health goals. Since an ALARA approach is based on the status of current technology, it is likely that the ALOP is achievable, provided a substantial portion of the industry complies with technological requirements or adopt "best practices" that will achieve the public health goal.

The selection of an ALOP based on public health goals focuses risk management on the target to be achieved, and also offers greater flexibility and encourages innovation. An example is the recent United States of America Juice HACCP Regulation, which is based on reducing the risk of food-borne disease to less than 1 reported case per 10 000 servings. However, a potential limitation of this approach is that unrealistic public health goals could be specified that are not achievable by industry within a realistic time frame. Furthermore, it may be difficult to continue to meet consumer expectations in terms of nutrition, cost and availability of the particular food.

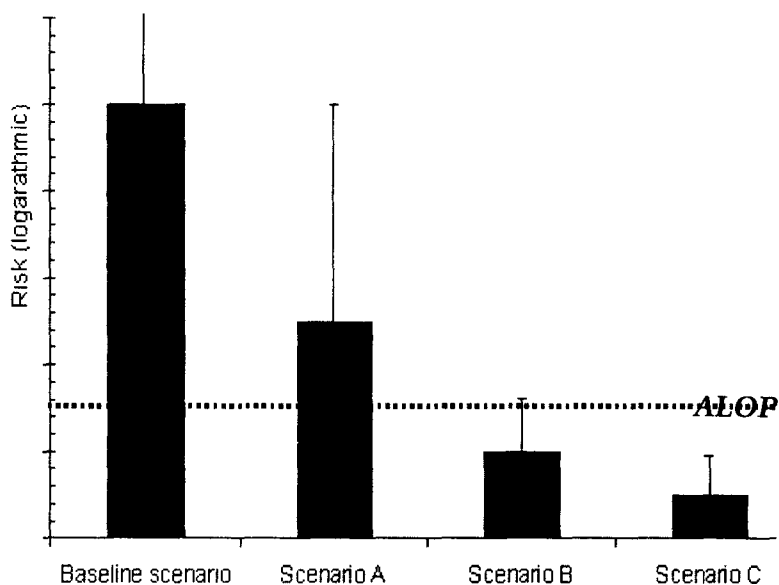


Figure 2. A comparison of the risk associated with different risk management intervention scenarios including the 95th percentiles (bars) of the risk estimate. The dotted line (named ALOP) identifies the level of risk considered to be the Appropriate Level of Protection.

Where the specific risk management goal is to reduce food-borne disease, the extent of that reduction compared with the current status will dictate the likely impact on the industry. A small targeted reduction in the reported disease incidence attributable to the food of concern is likely to affect only those members of the industry currently not meeting the degree of control expected from good hygienic practice (GHP) and existing regulatory requirements. A moderate targeted reduction in the reported incidence of disease is likely to require the industry-wide adoption of "best practices". A substantial

reduction is likely to require the adoption of new technologies. The reductions in disease incidence that are likely to be achieved for hazards associated with a specific food will be dependent on the inherent microbiological safety of that food and the current degree of sophistication within the industry.

A special case of the ALARA approach is the use of a benchmarked ALARA e.g. when a new technology, or alternative food control system, is being considered. The performance of the new approach is "benchmarking" against the current system to assure that the new system is at least as effective in achieving the required ALOP.

It is apparent from recent studies that MRA can significantly contribute to the elucidation of ALOPs and decisions on appropriate food safety measures (including the establishment of FSOs), irrespective of whether the ALOP is based on an ALARA approach and has been "arrived at" during evaluation of risk management options, or has been specified as a public health goal:

- MRAs on *Salmonella* Enteritidis in egg and egg products estimate current risks and examine alternative control measures as a means of reducing the disease burden. This is an ALARA-based approach and the MRA undertaken in the United States of America has been used to establish egg-handling practices within that country. That MRA is now being expanded and updated as competent authorities have been given a mandate to reduce the reported incidence of *S. Enteritidis* infections associated with egg products by 50% by 2010. Thus, the new mandate represents an ALOP based on a specific public health goal. The FAO/WHO MRA was being conducted to estimate the risk for the

general public and susceptible sub-populations, and to estimate the effectiveness of particular risk management interventions.

- MRAs on *L. monocytogenes* in ready-to-eat foods provide information on how different FSOs impact on the current reported incidence of disease. In the case of the United States of America, the risk management goal was to reduce the reported incidence of food-borne listeriosis to 0.25 cases per 100 000 population, and the MRA was conducted to determine which foods needed to be targeted for risk reduction measures to achieve that goal. The FAO/WHO MRA was conducted to estimate the risk for the general public and susceptible sub-populations, to compare the effectiveness of different risk management strategies and to estimate the risk from foods that support the growth of *Listeria* compared to those that do not.
- Product-pathogen pathway analyses were undertaken for *Escherichia coli* O157:H7 in ground beef to help make ALARA-based decisions to reduce food-borne risks due to enterohaemorrhagic *E. coli* (EHEC) infections. The goals of the MRAs were to identify the likely reductions in the incidence of disease that could be achieved by interventions at various steps within the production-to-consumption pathway.
- A MRA for *Vibrio parahaemolyticus* in raw oysters was undertaken in the United States of America to revise a current microbiological standard so as to decrease gastroenteritis associated with raw shellfish. The MRA estimated the baseline incidence of disease without interventions. The model was then used to evaluate the impact of

different technologies for the reduction of *V. parahaemolyticus* on the incidence of disease. Thus a combination of specific public health and ALARA goals were addressed.

Using MRA to Ensure Achievement of an ALOP

Risk characterisation combines the information generated in the hazard identification, exposure assessment and hazard characterisation steps of the risk assessment to produce a complete picture of risk. The result is a risk estimate, that is an indication of the level of disease resulting from the given exposure. Whenever possible, the resulting risk estimate should be compared with epidemiological data, or other reference information, to assess the validity of the models, data, and assumptions used and developed in the MRA. The risk estimate should present a distribution of risk that represents for example the variability in the level of contamination of the food by the pathogen, factors that affect growth or inactivation, and the variability of the human response to the pathogen. The uncertainty in the overall model used to arrive at the risk estimate should be articulated separately.

Different exposure scenarios evaluated in the MRA will yield different estimates of risk, which can be compared with expectations in terms of ALOP. The selection of the preferred risk management option might also be based on a central tendency of the risk estimate.

It is important to recognise that risk estimates are always uncertain. There are different sources of uncertainty, some of which can be fully included in the model and can be analysed by simulation. In those cases, the output of the model will be a distribution that characterises the "degree of belief " in the risk estimate.

The risk manager will have to decide the degree of confidence they want to have that the ALOP will actually be met, with 95% confidence often being used. In that case, the risk characterisation graph can be expanded with the 95-percentiles of the risk estimate (Figure 2).

Establishing FSO

Whilst expression of an ALOP in terms relevant to public health, e.g. the reported number of cases per 100 000 population serves to inform the public, the ALOP is not a useful measure in the actual implementation of food controls throughout the food chain. Implementation of food safety controls can greatly benefit from expression of the ALOP in terms of the required level of control of hazards in food. This provides a measurable target for producers, manufacturers and control authorities and is the basis of the FSO concept. As an example, it could be considered by risk managers that listeriosis at a reported rate of 0.5 cases per 100 000 in a given population should be reduced by one half. The only way this goal can be translated into appropriate food controls is to determine the new level of hazard control that is required in the food.

Definition of a FSO

The CCFH has agreed that a working definition of an FSO as proposed by the ICMSF is “the maximum frequency and/or concentration of a microbiological hazard in a food at the time of consumption that provides the appropriate level of protection”. A theoretical example of the application of this definition could be: less than one colony forming units (CFUs) per hundred (100 ml) servings of fresh apple cider contains *Salmonella*. The FSO definition is based on the fact that the risk

characterisation component of the MRA relates the risk of becoming ill to the frequency and/or concentration of the hazard at the point of consumption.

It is recognised that FSOs will usually need to be used in conjunction with performance criteria and/or performance standards that establish the required level of control of the hazard at other stages of the food chain. In most cases, the level of hazard control that is required at earlier stages in the food chain before consumption differs from the FSO. For example, if a FSO for *Salmonella* in fresh apple juice is "a frequency of one CFU in 100 servings at the point of consumption", the required level of hazard control earlier in the chain will need to be much greater because of the potential for growth. An MRA can be used to determine such relationships.

Translation of an ALOP into a FSO

Expression of an FSO as the frequency and/or concentration of a hazard in the food, is quantitatively linked to the ALOP by integrating the variability distribution of the exposure assessment with a dose-response curve i.e. risk characterisation. More work is needed to unite the FSO concept with the probabilistic nature of MRA, so as to derive appropriate values for FSOs.

The uncertainty associated with the model and the epidemiology, specific confounding factors, and the fact that the risk characterisation is based on distributions must be taken into account when deriving an FSO. Because of the considerations of uncertainty and variation inherent in MRA, the FSO may be set at a lower value to ensure that the desired level of consumer protection is achieved.

Factors influencing the establishment of an FSO

A number of considerations should be taken into account when establishing an FSO. If, for instance, market surveys have revealed that products fall into two categories i.e. low ("safe") hazard levels and high ("unsafe") hazard levels, the FSO that is established may constitute a decision to eliminate the latter category from the market, thus reaching the desired level of protection.

Establishment of an FSO will likely be an iterative process involving relevant interested parties and including risk assessors. Risk managers may not altogether realise the full range of risk management options they would like to consider until they reach the stage of setting an FSO e.g. following the preliminary report on the work undertaken as part of the FAO/WHO MRA on *L. monocytogenes* in ready-to-eat foods to the CCFH, the committee more specific questions to the risk assessment team including an estimation of the difference in risk resulting from FSOs varying between "absence" (0 cells/25 g) and 1000 cells/g.

Once an FSO has been established, it may be necessary to provide explicit guidance to processors on limits in terms of the frequencies and/or concentrations of hazards that are acceptable at specific steps in the food chain. These limits may also be expressed in terms of processing criteria that have been validated as achieving the required levels of hazard control e.g. heating specifications.

Setting an FSO without an ALOP

An FSO can, and most often is, set even when a risk assessment representing risk and distributions in mathematical terms is not available. Consequently the risk characterisation is not available. Investigations of

food-borne diseases, epidemiological surveillance programmes, industry records and knowledge of the influence of food processing parameters can provide information about which foods cause adverse health effects, which pathogens are implicated, and, to some extent, the levels of pathogens involved. In effect, the setting of microbiological criteria for foods has been, and is, an indirect way of setting an FSO - and thus implies a desired public health goal. Many examples are available. One is the standard for *Staphylococcus aureus* in cooked crustaceans at 100/g. This criterion contains an evaluation of the risk related to the concentration of the hazard.

Setting FSOs for foods in international trade

If a FSO is to be established, it will be the responsibility of national competent authorities. However, the development of internationally acceptable "benchmark" FSOs could be very useful for the purposes of trade. Where FSOs can be established, judgement of the equivalence of alternative food safety measures should be greatly facilitated. It must be remembered that both the level of a hazard in food and consumption must be considered in estimating the level of risk.

Establishment of FSOs by importing countries should allow for flexibility and innovation in the way exporting countries can achieve the required level of consumer protection. This may provide a distinct trading advantage to developing countries. However, a trade-off for this flexibility is the need to validate the equivalence of different food safety measures. Guidelines can also be provided on default criteria (fail-safe criteria) for certain control measures that have been validated as achieving FSOs. These criteria, developed by expert groups, are intended to control hazards under "worst-case" situations.

Communicating the Evaluation of Risk Management Options

Iterative communication by risk managers during and following evaluation of risk management options is critical to effective selection and implementation of such options. Risk managers must be prepared to obtain and consider input from relevant interested parties. Risk managers should also present a broad strategy for how they intend to implement new risk management options.

Risk managers must be prepared not only to announce results, but also to provide the rationale for their decisions and the implications of the results to all interested parties. While much of this would have been made available during iterative communication with interested parties in the establishment of ALOPs and consideration of different risk management options, it is important that the assumptions, conclusions, and interpretations associated with the final decision be formally transmitted and archived.

When proposing a new or modified ALOP and/or FSO, the risk managers should be prepared to meet with interested parties as an integral part of the decision-making process. This includes providing specific information on how a MRA may have been used in developing the proposed ALOP and/or FSO. For that purpose, it is advisable that an individual skilled in communicating MRA concepts and results be included as a member of the team that will communicate the proposed ALOP and/or FSO. Specific issues are:

- The degree to which public health will be improved as a result of the new ALOP and/or FSO;
- The relationship between the ALOP and the FSO;

- How the new ALOP and/or FSO fits into a program for continual improvement of public health;
- Whether further changes in the ALOP and/or FSO are anticipated in the future.

Following evaluation of risk management options, risk managers should be prepared to provide a detailed rationale for why certain options were considered viable while others were considered either incapable of, or inappropriate for achieving the ALOP and/or FSO. This is particularly important if the options selected are limited. Sometimes, potential options will not be selected because insufficient data were available to determine if the option would be effective. The risk managers should then be prepared to articulate the types of information necessary for additional risk management options to be considered in the future, and the process by which new options will be considered. Risk managers should also be prepared to discuss how innovative approaches to achieving the ALOP and/or FSO will be further considered or even encouraged.

The risk managers should be prepared to discuss the impact of the option selected on the various segments of the food industry, including the possible impact on large versus small businesses, and on industrialised versus developing countries. The risk managers should also be prepared to articulate how the ALOP and/or FSO will impact on international trade, particularly if the values are more stringent than those recommended by Codex.

Since the above discussions are likely to be of major interest to many of the interested parties, sufficient time and attention should be devoted to this activity. This should include articulation of how additional interactive

communication efforts will be conducted to both disseminate and acquire practical information related to implementation. The risk managers should also be prepared to announce a schedule for implementation when the risk management decisions are announced.

Implementation

Implementation of the food controls, that were decided on during the evaluation of risk management options, can take many forms. A very wide range of food safety measures may be implemented, either alone or in combination, and these include development of regulatory standards, guidelines and related texts. All parties interested in food safety may be involved in implementation e.g. competent authorities, industry, retailers and consumers.

The use of MRA as the scientific basis for implementation of controls is the focus of this document, even though it is recognised that many food safety measures can be successfully implemented without the use of MRA. For example, significant reductions in food-borne risks to human health have been attributed to:

- Improvements in waste water management, availability of potable water for drinking and food processing, and education on the importance of hand-washing in the case of typhoid fever in the United States of America;
- Sealing off of the rectum with a plastic bag during dressing of slaughter pigs in the case of yersiniosis in Norway and Sweden;
- Vaccinating broiler chickens in the case of *S. Enteritidis* in the United Kingdom;

- Targeted consumer information programmes in the case of contaminated raw oysters in the United States of America.

Even when MRA is used in the development of food safety standards, it is imperative to recognise the underlying necessity of maintenance of GHP.

Standards

Categories of food safety measures

Where MRA is to be used to inform implementation of food controls, different categories of controls can be utilised. These include: specific standards that contain quantitative elements e.g. microbiological performance criteria; guidelines that contain qualitative elements and are more generic in nature e.g. codes of practice for particular food commodities, HACCP guidelines; and more general texts e.g. explanatory texts and general recommendations on design of food safety programmes and advice to consumers. Standards may have different elements at the national compared to the international level.

In other situations, the purpose of questions posed by risk managers may not be to develop standards, but to address wider food safety issues e.g. prioritisation of broad food safety policies. Here, implementation of risk management decisions will be manifest in a variety of ways.

Compliance and enforcement

Implementation of food controls usually includes specification of the role of competent authorities in ensuring compliance with regulatory requirements, and

enforcement actions that may result from non-compliance. In this context, traditional "command-and-control" approaches and verification by end-product testing have been largely replaced by risk-based regulatory approaches to food safety. In this contemporary environment, the primary responsibility for ensuring food safety rests with the food industry.

Use of FSOs in Implementation of Standards

Role of FSOs

If an FSO has been established during the evaluation of risk management options, both competent authorities and industry have the opportunity to develop food safety measures throughout the food chain that achieve the FSO. These include approaches based on GHP, HACCP and performance criteria. Availability of a FSO also facilitates validation and verification of the selected food safety measures e.g. MRA may be used to establish the levels of hazard control at different points in the food chain that are necessary to achieve the FSO. One or more control measures may be necessary to achieve the FSO.

In selecting food controls that are based on FSOs, competent authorities should have assured their feasibility, and should be able to recommend how to implement these measures. A decision may also be taken to adopt Codex standards, guidelines and related texts that are based on an "international" FSO that is acceptable at the national level.

Correct use of an FSO in the implementation of food safety measures is the responsibility of the competent authority. This requires communication of the FSO to all interested parties. It is up to the competent authority to decide in which manner the FSO is included in the

national regulatory framework e.g. as a food safety measure in it's own right, or as the parameter upon which standards, guidelines and related texts are based. In some cases, the competent authority may translate the FSO into a general food safety measure e.g. risk managers may better achieve an FSO for *V. vulnificus* in raw oysters by implementing a consumer information programme rather than by attempts to implement specific controls during growth or harvesting of oysters. In other cases, a performance criteria to achieve the FSO may be established at one or more steps in the food chain.

Establishment of Performance Criteria

When designing and controlling food processing systems it is necessary to consider microbiological contamination, destruction, survival, growth, and possible recontamination. Consideration should also be given to subsequent conditions to which the food is likely to be exposed, including further processing and potential abuse during storage, distribution and preparation for use. The ability of those in control of foods at each stage in the food chain to prevent, eliminate or reduce food-borne hazards varies with the type of food and the effectiveness of available technology.

When a FSO has been established to express the level of a hazard at the time of consumption, another term is needed to describe required levels of hazard control at other points of the food chain. Performance criteria can be used to fulfil this role. For the purposes of this document, a performance criterion is defined as "the required outcome of a step or a combination of steps that contribute to assuring that a FSO is met".

The establishment of a performance criterion can be a competent authority and/or an industry activity. In both

cases it is the industry's responsibility to meet the criterion. Whenever a competent authority changes a criterion, this should be communicated to all relevant parties.

When establishing performance criteria, consideration should be given to the initial level of a hazard and changes occurring during production, distribution, storage, preparation and use of the food.

Implementation of performance criteria

Performance criteria, alone or in combination, may be implemented as food safety measures in GHP- and/or HACCP-based food control systems. In the context of HACCP, a food safety measure is "any action and activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level" and a critical control point (CCP) is "a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level". A performance criterion can be set at any step in the food chain, and specifies at least the same level of hazard control as the "acceptable level" to be achieved at a CCP. The availability of a FSO allows validation of performance criteria as appropriately contributing to the achievement of the required ALOP.

Many raw material, processing, distribution, storage, preparation and food use scenarios have to be taken into account in the implementation of food control systems that incorporate performance criteria. Different scenarios can provide different food control options, and improvements in food safety, i.e. leading to different FSOs, can be simulated using MRA. These simulations can also be useful in the establishment of CCPs and critical limits in generic HACCP plans.

Specific work carried out by HACCP teams during product development or during the study of an existing production takes into account the microbiological condition of the raw materials used, what the actual processing conditions are, as well as what is happening with the product after it leaves the production site. If the level of the hazard at the time of consumption is estimated to be higher than the FSO, food safety measures have to be altered and/or new performance criteria introduced in order to remedy the situation.

Where foods do not support microbiological growth e.g. a stable RTE food, a performance criterion established at a step immediately after processing may be the same as the FSO. However, industry may want to build in a "safety factor" in order to be "on the safe side". This attempts to take into account the possibility that some abuse may occur during further handling but that this abuse should not lead to food-borne illness. The magnitude of this "safety factor" may be the result of an analysis of distribution, sales, preparation and use practices carried out during hazard analysis in the application of HACCP principles, or may be derived from the exposure assessment of a MRA. In the latter case, inclusion of a safety factor in a performance criterion is likely to be particularly important when the risk estimate is highly uncertain.

When microbial growth will occur after a product leaves the processing establishment, a performance criterion will be more stringent than the FSO. This would apply, for example, to certain RTE products with extended shelf-life in which *L. monocytogenes* can multiply. On the other hand, the performance criterion can be less stringent than the FSO when a particular product will be cooked before consumption and when the

reduction of the hazard during this preparation step, in combination with the initial level, would assure that the FSO would be met. Salmonellae in broilers is an example of this, where application of GHP during preparation and cooking should assure that the FSO is achieved.

Theoretical examples of the possible use of MRA in implementing performance criteria

A MRA conducted by FAO/WHO predicted that the risk of illness due to salmonellae on broilers is $<1.66 \times 10^{-6}$ per serving. This estimate is based on a prevalence of 20% carcasses being contaminated with salmonellae after processing. During evaluation of risk management options, an ALOP could be expressed as a 50% reduction in the current levels of illness. The most effective way to achieve this ALOP might be to establish and implement control measures that included performance criteria for raw broilers after dressing or chilling. Simulation studies using the FAO/WHO MRA model predicted that reducing the prevalence of salmonellae on raw broilers emerging from the chill tank by approximately 50% would reduce the risk of illness per serving by approximately the same amount. A prediction such as this must be treated with caution as the FAO/WHO MRA model was incomplete in terms of some exposure components e.g. cross-contamination at steps in the food-chain subsequent to chilling was not included. Notwithstanding the need for further MRA inputs and validation studies, implementing a performance criterion that states "no more than 10% of carcasses emerging from the chill tank are contaminated" would theoretically achieve the ALOP as stated above. The food safety measures necessary to meet the performance criterion would include on-farm measures such as vaccination programs, and/or intervention measures aimed at

minimising contamination during slaughter and handling of raw broilers.

V. vulnificus in raw shellfish represents another theoretical example. This organism is present in the marine environment and is capable of colonising shellfish within the environment. A hazard analysis of distribution and consumption of this food reveals that with current processing and storage practices, no CCP exists. Thus the organism survives the harvesting and transport steps, and the typical storage conditions (refrigerated storage > 0°C does not guarantee against growth to hazardous levels). As a consequence, it would be extremely difficult to produce edible, viable shellfish, such as raw oysters without the sporadic occurrence of the organism.

A dose-response relationship for *V. vulnificus* is being developed as part of the FAO/WHO activities on microbiological risk assessment. This currently suggests that low levels of the *V. vulnificus* constitute a very low level of risk to the "normal" population. If an ALOP of one case of illness per million consumers was agreed upon, an FSO could be translated from the dose-response curve as X CFUs *V. vulnificus* per gram of seafood at the point of consumption. Performance criteria would probably be based on time and temperature controls from the point of harvest to consumption. It may be possible to correlate known levels of *V. vulnificus* in the environment with levels of the organism in shellfish and then to calculate needed controls of the basis of predicted growth and death of the vibrios.

Establishment of microbiological criteria

Codex describes a microbiological criterion as "defining the acceptability of a product or a food lot, based on the absence or presence, or number of micro-organisms

including parasites, and/or quantity of their toxins/metabolites, per unit(s) of mass, volume, area or lot". As with performance criteria, microbiological criteria can function as valuable food safety measures, and the availability of a FSO allows validation of microbiological criteria as appropriately contributing to achievement of the required ALOP.

A microbiological criterion can be set by a competent authority or industry. General considerations concerning establishing and implementing microbiological criteria are presented in the Codex Alimentarius Food Hygiene Basic Texts. When dealing with specific foods, decisions on the steps in the food-chain where microbiological criteria are to be applied have to be made, as well as decisions on what would be achieved by applying them. Availability of a MRA to link microbiological criteria with a FSO is particularly valuable in this respect.

Specification of a microbiological criterion will involve full analytical specification, including micro-organisms to be measured, sampling plan, analytical method and microbiological limit.

Implementation of microbiological criteria

As with performance criteria, microbiological criteria may be implemented as food safety measures using either GHP or HACCP approaches.

A microbiological criterion may be used as an acceptance criterion in situations where the history of the food is not known e.g. at port-of-entry, retail outlets. Risk profiling should have been undertaken to link the pathogen with the food of concern, and it should also have been considered whether other acceptance criteria would provide a larger degree of safety assurance.

Careful consideration should be given to the choice of sampling plans and the degree of assurance they provide. Currently spreadsheet systems are available that allow determination of the performance of a particular sampling plan.

Use of MRA in the Implementation of Standards in the Absence of a FSO

A FSO is linked by definition to a decision on an ALOP. In many situations currently pertaining to food safety, risks associated with particular hazards may have been estimated by MRA, but a societal decision on ALOP may not have been taken. Nevertheless, MRA can be a valuable tool in the establishment of food safety measures in these situations.

Design of "Production-to-Consumption" Food Safety Programmes

Even though an ALOP and FSO may not have been established, modelling the effectiveness of different food safety measures in reducing risks to consumers can be a valuable application of MRA. Two examples include modelling the relative effectiveness of different measures throughout the production-to-consumption pathway for control of *S. Enteritidis* in shell eggs and egg products and modelling *E. coli* O157:H7 in ground beef to identify the likely reductions in risk that could be achieved by interventions at various steps in the production-to-consumption pathway.

Determining broad risk management goals

Where a ubiquitous pathogen occurs in a number of foods, a preliminary risk management goal may be to determine which foods should be targeted for more stringent food safety measures to achieve the greatest

reduction in overall food-borne risks e.g. *L. monocytogenes* in RTE foods. Relative risk reductions for particular hazard/food combinations can be predicted from MRA.

Modular components

The availability of a national MRA that is comprised of modular components allows its adaptation by other countries with different data inputs and/or different food safety needs. In respect of food in international trade, this allows implementation of national food safety measures that are fully justified in scientific terms and that satisfy the provisions and obligations of the WTO SPS Agreement.

Demonstration of equivalence

Demonstration of the equivalence of alternative food safety measures applied at different steps in the food-chain is becoming an increasingly important activity at both the national and international levels. Consideration of a risk management option that achieves the same level of consumer protection provides flexibility to industry, promotes innovation in food control, and facilitates contemporary regulatory approaches to verification and audit. Exposure assessment during MRA can detail the level of hazard control required at particular steps in the food chain, and facilitate demonstration of an equivalent level of hazard control using different food technologies or different food safety measures, for example computer imaging compared with organoleptic examination of offal at post mortem meat inspection, or different intensities of organoleptic post mortem inspection of carcasses.

Scientific Justification of Food Safety Measures at Port-of-entry

In some cases, the susceptibility characteristics of a

consumer population in a particular country may be such that more stringent food safety measures are needed than Codex standards. Such situations are well recognised for chemical hazards, and the increasing availability of detailed hazard characterisations for particular microbial pathogen/food combinations will likely result in similar applications.

MRA mandated by law or legislation

It is likely that the use of MRA in the development of food safety measures having a significant impact on industry will increasingly become a mandatory legislative requirement in some countries. These MRAs should indicate the likely decrease in risk associated with implementation of new food safety measures, either on a relative or absolute scale.

Monitoring and Review

An essential part of a risk management framework is the on-going gathering, analysing, and interpreting of data so as to determine how well risk management has performed and what steps may need to be taken next to better improve public health. Monitoring of contaminants in food and food-borne disease surveillance allows risk management strategies and food safety measures to be appropriately reviewed to show that: stated public health goals are being achieved, new food safety problems are identified as they emerge, and data is provided for future improvements in risk management strategies.

It is the responsibility of the risk manager to evaluate food safety risk management through the use of monitoring and review. The risk manager needs to plan how this component of will be conducted, how relevant activities will be undertaken, who will conduct these

activities, and what specific questions should be addressed. This should be a periodic process, and will normally be the responsibility of national competent authorities. In most cases, monitoring and review of public health outcomes will be a measure of the effectiveness of regulatory food control programmes.

Monitoring

Monitoring is used to help guide the selection, conduct and evaluation of a particular risk management strategy or action in addressing the food safety issue under consideration. Monitoring may also be more targeted so as to provide information on risks to human health from specific hazards and/or foods. In this respect, surveillance of human populations includes monitoring of sporadic cases, investigation of food-borne disease outbreaks, and trace-back to source of the likely causal pathogens.

Examples of monitoring are national and international databases of food-borne diseases, systematic investigation of food-borne disease outbreaks, and integrating data on human food-borne disease with data on hazards in the food supply e.g. the prevalence of infected animals at the level of primary production. In most cases, monitoring and surveillance of human populations and the analysis of human health data is the responsibility of national competent authorities.

Monitoring of contaminants in food and food-borne disease surveillance data are an important source of information for MRA. As well as contributing to the development of a risk profile, they provide important inputs to the development and validation of MRA models. For example, epidemiological data gained from surveillance activities has been used to generate a dose-

response curve in the case of *L. monocytogenes* in RTE foods. However, development of dose-response models in this way has some limitations, and prevents independent validation of the risk estimates generated by the MRA.

Monitoring of contaminants in food and food-borne disease surveillance activities should be tailored to collecting information that will be of highly useful in the development of future MRA models and in the evaluation of current risk management decisions e.g. provision of concentration as well as prevalence data for hazards in foods. Each MRA requires specific types of data, and benefits from standardised methodology in the collection of such data e.g. for modelling hazard levels throughout the food-chain during exposure assessment.

Review

Review of risk management strategies and food safety measures is necessary to assess whether or not the risk management strategy as a whole, or a particular risk management action, is successful in achieving the desired results and appropriately contributing to consumer protection. In the broadest sense, monitoring of the consumer population may indicate that current risk management activities are not delivering acceptable public health goals, and more stringent measures may need to be implemented. In other situations, targeted monitoring may indicate that review of a particular food safety measure is necessary.

In reviewing risk management strategies and/or actions, risk managers may find it desirable to request an independent review to assess how well the food safety issue under consideration, or a particular aspect of the food safety issue, has been addressed. The results of the review should be made public and communicated to

relevant interested parties. Based on the results of the review and the public input received, further activities may be initiated e.g., collection of additional and more targeted information, establishment of new risk reduction goals, or implementation of additional food safety measures. Part of the risk management and/or MRA activities may need to be repeated to ensure that the ongoing risk management programme is effective.

Specific risk management decisions should also be reviewed as appropriate and new information pertaining to food safety becomes available. This may arise in the form of new knowledge on for example the virulence of a particular pathogen in foods, the extent of exposure of highly sensitive consumer populations, changes in dietary intake, changes in food processing, and data from monitoring and/or targeted epidemiological studies. New information should be compared to the information that was previously used by risk assessors and/or risk managers, to determine the likely impact on the MRA or the selection of a particular risk management option e.g. new information on food consumption patterns and food preparation practices may indicate that certain population groups are at greater risk than previously thought, and assessment of risk management options will need to be revisited taking the new information into account. In other situations, new information may become available on the effectiveness, cost, or unanticipated consequences of a particular technology, thereby changing the inputs to assessment of risk management options and the final risk management decision.

Use of MRA in monitoring and review

The availability of a MRA can provide substantial benefits to monitoring programmes. Hazard characterisation during MRA should indicate the range of

adverse health effects that may result from a particular hazard/food exposure pathway, and monitoring to determine the effectiveness of food safety measures should be linked to the parameters used to assess risk and agree on an ALOP e.g. daily-adjusted life years (DALYs).

A MRA could be used to predict changing risks from the same hazard-food commodity, and facilitate design of monitoring programmes so as to effectively validate such predictions e.g. differences due to season, region or country. Also, MRA may be used to explain apparent changes in reported incidences of food-borne disease that may have been brought about by different laboratory methods, intensified reporting systems or increased awareness of a particular food-borne disease.

A MRA may serve as a check on representativeness of data on human health risks gained from monitoring. Where predictions on risk from the MRA do not match monitoring or surveillance data, further scientific investigations will be required e.g. investigation of the sensitivity and specificity of the monitoring programme.

It is clear from the above discussion that review of risk management decisions will be much enhanced in all circumstances by incorporating new inputs in a MRA model.

"This page is Intentionally Left Blank"

Bibliography

- Alamgir, M. and Arora, P., *Providing Food Security for All*, IT Publications, London UK, 1991.
- Anon, "Disinfection of Rural and Small-Community Water Supplies", *Water Research Centre*, Medmenham, Bucks, UK, 1989.
- Buelow, F.H., "Drying crops with solar heated air", *Proceedings of UN conference on New Sources of Energy*, FAO, Rome, Italy, 1961.
- Dowson, V.H.W. and Aten, A., "Dates: Handling, Processing and Packing", *FAO*, Rome, Italy, 1962.
- Fellows, P. and Hidellage, V., *Making Safe Food (Book and Posters)*, IT Publications, London, UK, 1992.
- Hobbs, B. and Roberts, D., *Food Poisoning and Food Hygiene*, Edward Arnold Ltd, 41 Bedford Square, London WC1B 3DQ, UK, 1987.
- Hope, G.W. and Vitale, D.G., "Osmotic dehydration - a cheap and simple method of preserving mangoes, bananas and plantains", *Report IDRC 004 el. International Development Research Centre*, Ottawa, Canada, 1972.
- Howard, J., "Safe Drinking Water", *Oxfam Technical Guide*, Oxfam, Oxford, UK, 1979,
- ILO, *Solar Drying: Practical Methods of Food Preservation*, Geneva, Switzerland, 1986.
- ITC UNCTAD/GATT, *Quality Control for the Food Industry*, Geneva, Switzerland, 1991.

- Jowitt, R., (Editor), *Hygienic design and Operation of Food Plant*, Ellis Horwood Ltd, Cooper Street, Chichester, PO19 1EB, UK, 1980.
- MacDonald, I. and Low, J., *Fruit and Vegetables*, IT Publications, London, UK., 1984.
- Pickford, J., Barker, P., Coad, A., Dijkstra, T., Elson, B., Ince, M., and Shaw, R (Editors), *Affordable Water Supply and Sanitation*, IT Publications, London, UK, 1995.
- Quiros, R.D., Madrigal, A., Samuals, L., Aguilar, A., Orfiz, F., Fernandez, R. and Cooke, R., "Fruit and Vegetable Processing, Appropriate Technology in Costa Rica; A Case Study", *Tropical Science*, 1980.
- Sprenger, R.A., *The Food Hygiene Handbook*, Highfield Publications, Doncaster, DN5 7LY, UK, 1996
- Wood, B.J.B., (ed), *Microbiology of Fermented Foods*, Elsevier, London, 1985.

Index

- Acid builders 77
- Acid-anionic sanitisers 87
- Alkaline builders 76
- Anti-oxidants preservatives 124
- Appropriate Level of Protection (ALOP) 195
- Biological Oxygen Demand (BOD) 75
- Botulism 147
- Butylated HydroxyToluene (BHT) 124
- Campylobacter infections 173
- Canning salt 129
- Carbohydrate-based soils 72
- Chemical Oxygen Demand (COD) 75
- Chemical sanitising 79
- Clean- in-Place (CIP) 67
- Clean-out-of-Place (COP) 67
- Clear coating 113
- Clostridium perfringens 169
- Columbus 4
- Converted rice 99
- Critical Control Point (CCP) 201
- Defrosting 15
- Environmental Protection Agency (EPA) 80
- Escherichia Coli 170
- Fat-based soils 71
- Food allergens 90
- Food and Drug Administration (FDA) 80
- Food decays 151
- Food Safety Objective (FSO) 195
- Generally Recognised As Safe (GRAS) 124
- Genetically Modified (GM) crops 180
- Good Hygiene Practices (GHP) 180
- Good Manufacturing Practices (GMP) 180
- Granulated sugar 114
- Hazard Analysis and Critical Control Point (HACCP) system 23
- High Density PolyEthylene (HDPE) 125
- High risk foods 6
- Hot-water sanitising 78
- Human Leucocyte Antigen (HLA) 212
- International food trade 1
- International Organisation for Standardisation (ISO) 190
- Kashering 129

Kitchen hygiene 6

Manual cleaning 67

Mechanical cleaning 67

Microbiological films 72

Mineral salt-based soils 72

Paste wax method 113

Protein-based soils 71

Quality Assurance (QA) 187

Quality Control (QC) 187

Quality Management (QM) 187

Quaternary Ammonium Compounds (QACs) 85

Salmonella Gastroenteritis 167

Sanitation Standard Operating Procedures (SSOP) 187

Sea salt 130

Solar salt 130

Spice trade 4

Spray silicone 113

Staphylococcus Aureus 166

Sugar fungi 132

Thermal sanitising 78

Tolerable Level of Risk (TLR) 195

Total Quality Management (TQM)
187

Ultra High Temperature (UHT)
111

Vacuum canning 111

Water conditioners 77

White rice 99