Quality assurance for small-scale rural food industries

FAO AGRICULTURAL SERVICES BULLETIN No.117

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Food and Agriculture Organization of the United Nations
Rome, 1995

Table of Contents

M-81
ISBN 92-5-103654-3

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Contents

Preface

Contents - Next

For the preface of this book the authors felt that the following article, written by a food technologist from an African country - who is clearly frustrated at the lack of quality assurance, would highlight the real situation in some food manufacturing enterprises and demonstrate the need for more attention to quality assurance.

It is hoped that this small book will provide readers with the basic knowledge to start applying total quality assurance to their processes and so avoid the pitfalls described below.

"In this article I would like to look at some of the companies I have visited in which basic hygiene rules are so flagrantly flouted. The employee is a prime determinant of final product quality; hence rules about washing hands before contacting foods, use of utensils to handle products, disposable gloves, clean clothes, and protected hair need to be applied regardless of the size of the operation.

In practice what can be seen? An employee happily picking his nose while waiting for the next can on the line to fill. Meanwhile a colleague is sweeping up a cloud of dust right in the middle of the production line. At the change of shift a casual worker rushes in and quickly changes into soiled overalls and goes to the production line. He shakes his (unwashed) hands with those around. Washed hands and gloves do not feature. Late in the shift the worker goes to a dark corner for a sleep while colleagues cover for him. Rules are being ignored whilst management complain about the cost of providing clean protective clothing daily.

Even where basic processing standards are being met they are often undermined by post-processing operations. In one example seen, the rate of production far exceeds the rate of packaging. Here the excess baked product is put into large open sacks for later packaging. Under the steamy conditions in the plant it picks up moisture and becomes soggy. Workers, as they pass the sacks, dip in for a snack. The basic rules state that finished stock should be kept in separate stores. But what do we often see? Poor store management with final products in the same room as rejected raw materials and old flour bags.

All too often basic safety rules are flouted while consumers look on and public health officials turn a blind eye. In meat handling (a very high risk area) rules state that raw meat should be transported in a sealed compartment made of food-grade material, impermeable floors and with ventilation. In my country, meat is commonly distributed in pick-up trucks with a crude metal bin in the back. It is made of any metal, poorly sealed and not ventilated. The meat is simply dumped in and it then sweats as it is moved to the market. The whole system is conducive to microbiological growth. At the point of delivery the meat is hoisted onto the shoulders of a porter wearing a dirty, bloodstained coat.

Consumers, law-makers and public health officials look on, accepting such standards as a necessary evil in a game of hide and seek with microbes and germs.

But who is to blame for this often prevailing state of affairs? In my humble opinion all those involved: management for failing to provide guidance, workers for a lack of sense of duty, consumers for silently accepting the situation and the regulatory agencies for looking the other way.

As worldwide competition increases, manufacturers in African countries will have to improve their hygiene standards to have a chance of survival. Accolades will not be awarded to mediocre performance and the final arbitrators, the consumers, will vote with their feet and buy where quality and safety are assured."

Contents - **Next**

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Acknowledgements

Contents - **Previous** - **Next**

The authors greatly acknowledge the help and assistance given by Ann Watts for editing the manuscript, Matthew Whitton for the illustrations and Calvin Onyango for permission to use his article as the preface.

Contents - **Previous** - **Next**

Introduction

Contents - Previous - Next

In most countries the safety and quality of foods is becoming a matter of increasing concern. Information is more readily available to consumers through the mass media and they are considerably more aware of existing and potential risks from pesticides, food poisoning and a poor diet. The impact of this greater awareness can be seen with consumers preferring to buy foods that are made by larger manufacturers, for example, a plastic bag of well dried fish rather than loose dry fish from a basket in a market. The small and medium scale food processor is thus well-advised to pay heed to this rapid change in customers attitudes if they are to survive in business. This book is targeted at such small food manufacturers and the agencies that can assist and advise them. Its purpose is to present the basic principles of quality assurance to satisfy customer demands and safety. Hopefully it will guide food manufacturers, however small, on how to improve their particular production unit, keep up to date with a changing world and stay in business.

After introducing the basic principles and differences between quality control and quality assurance, the comparatively new management tool of Hazard Analysis and Critical Control Point systems (HACCP) is briefly described. These aspects are then related to four specific sub-sectors: baking, fruit processing, cereal or oilseed milling and herb and spice processing in order to show, in a practical way, how small, rural enterprises can implement appropriate quality assurance systems at low cost.

Quality improvement and control is not easy, particularly for very small manufacturers who may feel isolated. For this reason this publication ends with a series of appendices which list relevant publications, useful contacts and simple test methods.

However, in a publication of this size it is not possible to describe in detail every aspect of quality assurance and quality control and the reader is therefore advised to consult these publications and contact institutions for further information.

Glossary

Aflatoxins	dangerous poisons produced by moulds of the Aspergillus species, found in cereals, oilseeds and nuts when incorrectly dried and stored.
Acid preserves	foods that have a high acid content that inhibits spoilage.
Adulteration	deliberate contamination of foods with materials of low quality.
Average weight	a known proportion of containers have a fill-weight above system that shown on the label.
Bulk fermentation	the whole of the dough is fermented at 27C in a closed container to prevent surface drying.

Capacity of flour	used to calculate bakery recipes.
Case hardening	the formation of a dry skin on a wet food due to over-rapid drying. It slows the rate of drying and can lead to spoilage during storage.
Chlorination	the addition of chlorine to water to destroy micro-organisms.
Composite flours	mixtures of wheat flour (usually more than 80%) with other flours such as maize, rice, sorghum etc (usually less than 20%)
Conditioning	standardisation of the moisture content of grains or oilseeds before milling.
Contamination	materials that are accidentally included with a food (eg dirt, leaves, stalks etc).
Critical control	stages in a process where quality control can have a major points effect on food quality.
Critical faults	those faults in a product or package that would injure a consumer or cause substantial financial loss to the producer.
Cross contamination	the transfer of soils or micro-organisms from raw food to processed.
Crumb	the internal structure of baked products, especially bread and cake.
Detergent	a chemical that removes soils but does not sterilise equipment (see soils below).
Enzymes	natural proteins in foods that can cause changes to colour, flavour or texture of the food.
Equilibrium relative	the moisture content at which a food does not gain or lose weight

humidity (ERM)	and is stable during storage.
Fill-weight	the amount of food placed into a container or package and written on the label (also net weight).
Final proof	tinned loaves are placed in a prover at 35C (85-90% RH) until desired height is reached before baking.
Gelatinization	swelling and rupturing of starch grains due to heat and of starch moisture.
Gluten	a protein found in wheat that gives the characteristic crumb structure to bread.
HACCP (Hazard Analysis Critical Control Point) system	a system used to identify and control contamination in food processing.
Headspace	the gap between the surface of food in a container and the underside of the lid.
High risk foods	those foods that are capable of transmitting food poisoning micro-organisms to consumers.
Humidity	the amount of water vapour in air.
Hydrometer	an instrument that measures specific gravity of liquids, used to measure salt, sugar or alcohol concentration.
Low-acid foods	foods that have little acid and therefore can contain food poisoning bacteria if poorly processed.
Micro-organisms	tiny forms of life, including moulds, bacteria and yeasts, that are invisible until they are in large numbers.

Minimum weight	all packages have a fill-weight equal to system or greater than that shown on the label.
Moulding	process of passing dough through a moulding machine prior to filling into baking tins.
Net weight	the amount of food filled into a container.
Pectin	a natural gelling agent found in some fruits
pH	a scale used to express acidity or alkalinity, from 1 (strong acid) through 7 (neutral) to 14 (strong alkali).
Potable water	drinkable water that will not cause illness.
Preservation index	a figure that is calculated to show that the amounts of acid, sugar and salt used in pickles will be enough to prevent spoilage.
Quality assurance	a management system which controls each stage of food production from raw material harvest to final consumption.
Quality characteristics of a food.	a set of descriptions that identify the specific quality features
Quality control	a series of checks and control measures that ensure that a uniform quality food is produced.
Refractometer	an instrument that measures the refractive index of a liquid, which is used to measure soluble solids in syrups, jams and marmalades, or salt in brines.
Rope in bread	bacterial spoilage that produces rope-like threads in bread and can cause food poisoning.

Scaling	dividing of dough into pieces of equal weight.
Shelf life	the time that a processed food can be stored before changes in colour, flavour, texture or the number of micro-organisms make it unacceptable.
Sodium benzoate	a chemical preservative that is particularly effective against yeasts.
Sodium metabisulphite	a chemical preservative that is effective against moulds and yeasts.
Soils	any material that contaminates equipment (ea. grease, scale, burned on food or other food residues).
Sterilant	a chemical that destroys micro-organisms but does not remove soils.
Strong flour	wheat flour that has a high level of gluten.
Sugar preserves	foods that have a sufficiently high sugar content to stop spoilage.
Thief sampler	equipment to take samples from sacks of food.
Titration	a method of accurately adding one liquid to another, commonly used in food analysis.
Water absorption	measurements that indicate how much water can be held in a dough.

Contents - Previous - Next

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Chapter 1 Basic principles

Contents - Previous - Next

1.1 The importance of quality assurance

Small and medium sized food processing businesses all over the world increasingly have to consider the production of good quality products as essential to their survival. Consumers and buyers are becoming more aware of the importance of safe, high quality products. Large companies that can afford advertising space on the radio, television or in the press emphasise the quality of their goods, often in a very subtle way. This quality image is given by stating for example "our foods are made only from high quality ingredients." They also project a quality image through packaging etc. Producers who sell intermediate products, such as dried fruits, to a secondary processor will find that the buyer expects the foods to meet an agreed standard. In the case of exporters, these standards are becoming more and more strict.

In order to improve and control product quality it is essential to fully understand the meaning of the term quality. A common definition is "achieving agreed customer expectations or specifications". In other words, the customer defines the quality criteria needed in a product. To meet this standard the manufacturer puts in a Quality Control System to ensure that the product meets these criteria on a routine basis.

1.1.1. Quality control or quality assurance

The following examples using baked goods illustrate the difference between quality control and quality

assurance. A customer may specify that bread should be white, with a good loaf volume and pleasant flavour and taste. The manufacturer then needs to focus on the process to ensure that the raw materials are consistently handled to produce uniform white loaves with the expected volume and taste.

Controlling quality may be achieved by:

- **Inspection of raw materials to ensure that no poor quality ingredients are used.**
- **Carrying out checks on the process to ensure that the weights of the ingredients and temperature and time of baking are correct.**
- **Inspecting the final product to ensure that no poor quality loaves are sent to the consumer.**

However, this Quality Control approach is focused on the process whereas the problems that customers may face can also occur elsewhere in the production and distribution chain. The following examples highlight the shortcomings of a simple quality control approach.

Problem:	Many of the loaves are contaminated with pieces of wood.
Reason:	The distribution system involves transporting the loaves on wooden trays to retail stores where the loaves are packaged and then sold to customers. The wooden trays are not part of the quality control system because they are used after the product has left the bakery.
Problem:	A particular customer has asked for loaves of a different size and colour but these do not arrive as requested.
Reason:	The sales staff have no formal procedure for informing the production staff about changes in this customer's specification. The problem has occurred

	because of missing links in quality management in the bakery.
Problem:	Bread has been returned because of a bad flavour and some customers have complained that they have been made ill.
Reason:	The flour has been stored next to cleaning chemicals in the dry goods store. One old unlabelled chemical container has been found to have leaked. The company have no documented rules for the storage and handling of chemicals. The staff who routinely clean the store are not trained and receive lower wages than other members of the production team. The container is old and unlabelled (Fig. 1).

Figure 1: Hazardous storage of chemicals

In order to overcome the types of problems outlined above, a wider approach than quality control is required. This is termed Total Quality Assurance.

Quality Assurance systems take a much wider view of what is involved in satisfying customers' needs. The quality assurance system focuses on the prevention of problems and not simply on their cure. Curing problems is expensive and quality cannot be 'inspected into' a product.

A quality assurance approach therefore, includes the whole production and distribution system, from the suppliers of important raw materials, through the internal business management to the customer. Quality assurance systems should be documented in a simple way to show who has responsibility for doing what and when. The focus of quality assurance is prevention and this should mean that action is taken to meet a specification and prevent failures from occurring a second time. This is done by

planning, management action, agreements with key suppliers and other people in the distribution chain.

Quality assurance can only be operated when staff are well trained and motivated. Workers are normally well aware of the causes of most problems and when quality assurance is used properly they can resolve most quality problems within their control. It is the responsibility of business owners to ensure that the quality assurance system, together with any necessary equipment and information, are available to the workers to allow them to exercise this control. The importance of people in quality assurance is represented in Fig. 2.

Figure 2: Good staff are important in quality assurance

It is important to recognise that any system is operated by people. It is people who manufacture a food product and ensure that it has the right quality. People working together ensure that the information, materials and equipment are all correct to allow the production of a product. People also store the product and deliver it on time. All therefore need the necessary training and skills to complete their tasks correctly. They need to know what their own responsibilities are in this quality chain and where they fit into the overall system.

Business owners must not regard communication as a one-way process. The information they send to workers must also be modified by feedback from the staff. Well trained and informed staff are an essential element of the Quality Assurance approach. The other main element of the quality assurance approach which ensures that the system works is to document in a simple way the procedures and responsibilities within a team of workers.

Consider the problems faced by the bakery described previously:

Problem 1 The use of wooden trays

This problem was related to the use of trays by the distributor. Who was responsible for arranging the contract with the distributor and specifying the use of wooden trays?

A quality assurance system ensures that this link in the chain is discussed by the manager and staff and that proper controls and arrangements with the distributor are put into place (for example, plastic sheets on the wooden trays). The producer needs to use the complaint information to modify the process and prevent the complaint occurring again. The types of complaints should be recorded, sources of the problem identified within the factory or supply chain and control measures put into place.

Problem 2 The customer requiring special bread

The internal business communication broke down and important information did not reach the production staff.

A quality assurance system ensures that this communication is constantly operating and being improved. Responsibility and authority are defined and written down.

Problem 3 Tainted bread causing sickness

The management had not identified and controlled the potential hazard that improper handling and storage of chemicals can cause. The effective creation of a quality assurance system should include an assessment and development of methods to control or prevent

hazards.

Quality Assurance systems are not mysterious and need not be complex. They simply require the business to agree what are the customers' needs and then ensure that staff have the skills, materials, and information needed to deliver the promises that are made.... every time. A quality assurance system should not be static but it should be continually modified and refined.

This requires an investment in training people to ensure that the quality assurance system controls the essential steps in the whole manufacturing and distribution process to satisfy customer needs.

A range of problem solving techniques can be provided for process workers to use when trouble arises during production. These simple techniques are tried and tested. They involve problem identification, analysis of the cause, suggestions for solutions and implementation and feedback methods. These techniques allow the operators more control over their work and allow problems to be prevented rather than solved. More advanced statistically-based methods can be used for sampling plans and process optimisation but these are beyond the scope of this book.

One of the main building blocks used for developing a quality assurance system is the 'Hazard Analysis Critical Control Point' system which is described in the next section.

1.1.2 Analysing food processes to improve quality using hazard analysis

All food companies, including the smallest manufacturers, have a responsibility to provide consumers with safe, wholesome foods. Safety is not an option but it is an essential part of the planning, preparation and production of foods. Any lack of consideration of safety can result in a serious threat to public health. This is recognised by the law in most countries and serious penalties exist for those who contravene hygiene and food safety legislation. At present in many countries, enforcement staff are not always sufficiently resourced to be fully effective, but this situation is changing as consumers become more concerned about food safety.

An important management method to ensure the safety of foods is the Hazard Analysis Critical Control Point (HACCP) system. This is based on quality control, microbiology and risk management and it has been adopted throughout the world, although some countries have tailored the approach to the needs of their particular food sectors. Many small producers may consider that the development of HACCP systems is not feasible or appropriate to their current needs. However larger manufacturers and producer groups who export to industrialised countries are increasingly finding that HACCP is not a matter of choice but is demanded by the importing company. With time, it is likely that the use of HACCP will be more broadly required by food manufacturers. For this reason a brief description of the application of HACCP is included in this book and examples are given using a number of commodity groups.

This Chapter examines the basic principles and practical methods for implementing the HACCP approach that are adopted to analyse a process and identify where improvements are needed in safety or quality.

An understanding of problems of food safety and quality improvement can start in one of a number of different ways. It can begin for example with an analysis of customer complaints to identify their types

and frequency. However, in many developing countries the mechanisms and habit of reporting faults to a producer do not exist and many manufacturers have little knowledge of customers' reactions to their products.

An alternative approach is for the processor to carefully examine every stage in a process to see where and how improvements can be made in the quality and safety of the finished products. The aim of such an exercise is to focus the attention of operators and the manager on the prevention of problems rather than cures, by identifying potential hazards or quality failures and then developing preventative measures for their control.

To implement such an analysis it is necessary to first decide whether the work will focus on improvements to product quality or improvements to the safety of foods. These are obviously connected as food safety is one aspect of quality, but they should be treated as separate exercises.

The level of risks is then assessed and procedures are implemented to monitor and control these risks. If analysis of safety is selected, it is necessary to identify the hazards in a process. This is especially true for high-risk foods (those that can support the growth of food poisoning micro-organisms). If high-risk foods are involved then the severity of the hazard is greater and these food products must be investigated thoroughly as very stringent controls are needed. It is for this reason that inexperienced producers should not be encouraged to make high-risk foods such as canned meats and fish.

If quality improvement is selected, it is necessary to identify where a loss in quality is likely to occur in the raw materials or the process and then find methods to control the procedures that are used in order to improve quality in the finished product.

Most small-scale processors do not have the necessary skills or time to conduct such a study, and it is likely that assistance will be needed from other people who have the necessary experience. Ideally a small team of people should be assembled to effectively analyse the process and then develop and implement the improvements for the selected product. Those selected should have appropriate expertise of the product, the processing operations, microbiology and quality control. Staff from a manufacturer's association, the local Bureau of Standards, Government Regulatory Food Control Office, a University, Trading Standards Department or suppliers may be suitable resource people to assist staff from the food business itself.

For example if the focus of the group is to improve product safety it should conduct its work in the following way:

Gather information

- **Identify sources and routes of contamination by micro-organisms, biological, chemical or physical contaminants (Table 1). It is easier to select one type of hazard which is most important to the product and complete the analysis. Other hazards should then be reviewed later in decreasing order of importance and added to the plan of action.**

Table 1: Types of contaminant

Hazard	Example
Microbiological	yeasts, moulds; bacteria, viruses
Biological	bone, hair, insects, faeces
Chemical	pesticides, toxins, cleaning liquids

Physical	wood, string, dirt, etc.

- **Study the effect of the process on levels of contamination and assess the probability of micro-organisms surviving the process to grow in the finished product. This should include all parts of the process, from growing foods or buying ingredients to storage and consumption of the finished product.**
- **The production process for the food is then shown diagrammatically by constructing a process flow diagram (see Chapter 2 for examples), which is taken to the processing building and checked for accuracy.**

Find solutions

- **The team then prepares a diagram showing the hazards that have been identified and where they occur in the process. This should be the focal point for discussions by the team.**
- **The severity of risk of each of the above hazards should be assessed and any areas of doubt should be investigated further. An example of common questions that are used to assess the level of risk is shown in Table 2.**

Table 2: Examples of questions used to assess the level of risk in foods

What is the product formulation?

What types of micro-organisms are likely to be present in the raw materials?

What is the pH of the product?

What is the moisture content of the product?

Are preservatives used?

Will any of these factors prevent microbial growth?

What is the intended process?

This should be considered in relation to micro-organisms of concern. Stages in the process that destroy, reduce or allow survival of micro-organisms should be evaluated (including conditions of intended distribution and use, temperatures and times of processing, types of packaging, expected shelf-life, storage and final use).

How will the product be prepared for consumption, is there a risk of mishandling by consumers?

Will the product be consumed by susceptible people (for example children eating weaning foods)?

Implementation

- **The owner or manager of the business also needs to be fully convinced that the new procedure is necessary, or else it will fall into disuse after a short time. Operators need to be involved and made aware of problems so that they will understand why new procedures are introduced.**
- **Control procedures are introduced at the control points using a "decision tree" (Figure 3: Critical**

control point decision tree) to help in this procedure. Target limits and tolerances are given for each critical control point. Staff are trained how to operate the new methods and the limits that are placed on any variation from the specified methods.

Monitoring and documentation

- **· The group sets up a procedure to monitor the changes that have been introduced and to ensure that everyone involved in the process understands his or her responsibilities. A system for monitoring these is produced, together with a plan for corrective actions, should the tolerances be exceeded.**
- **· Where action is taken it should be clear who has the authority to make decisions and who is responsible for checking that the action was properly done. These responsibilities should be discussed and written down so that everyone is aware of each other's part in the new system. The system is checked and reviewed each year.**

When the focus is on quality improvement, a similar sequence of events is used. The quality problems are first identified and possible causes and solutions are discussed. If the problem is associated with poor quality raw materials or ingredients for example, this should be negotiated with suppliers and if needed, quality testing methods can be introduced with agreed tolerance limits. If the problem is associated with the process, for example a critical heating time, then improved process control measures are introduced. In all cases staff must be fully involved and trained so that the improved quality management is sustainable. The effects of any changes should be carefully monitored and

recorded.

Such systems need not be complex. Only limited documentation is required and this should assist the small scale processor rather than prevent flexible working. These simple systems are designed to control the key parts of the process and help producers to concentrate valuable manpower where it is most effective. Examples of how this can be done with specific commodities are described in Chapter 2.

1.2 Building design and equipment layout

The type of building in which food products are manufactured and the general level of plant hygiene have a major influence on product quality. In this chapter, basic principles of the correct design of buildings, layout, cleaning of equipment and worker hygiene are described.

Ideally a food manufacturer should have a building constructed specifically for the purpose, but in reality this rarely happens and an existing building has to be modified. If care is taken in the way that the building is adapted, it adds little extra to the total cost but it ensures that the unit is appropriate for food processing.

The Site

The location of the building is very important but is often ignored at the outset. The following examples are points that need consideration and many of relate to quality aspects:

- **Is the building situated close to the supply of raw materials?**
- **Are expected markets easily accessible?**

- **Is labour available locally and will workers find problems in getting to work?**
- **Is the building situated in a clean area or is it an area that has a lot of dust, waste or stagnant water nearby?**

The site should be on cleared ground, away from sources of insects, rodents or smells. It should have a good supply of potable water and if required, electricity. A road access for bringing in raw materials and packaging, and sending out products is usually essential (Figure 4: Selecting the correct site for a food processing building).

Buildings

The external appearance of the building is a key factor that can influence customers to believe that the company has good management (Figure 5: Examples of a suitable and unsuitable building for processing foods). The points described below can enable quality assurance procedures to be better implemented. Externally and internally the building should be clean and painted, with a professionally made nameplate. Ideally the surrounding area should be planted with grass, as short grass acts as a very efficient trap for airborne dust.

Washing and toilet facilities must be provided, preferably in a separate building. If this is not possible there must be two closed doors between the toilet and the processing area to prevent insects and odours from entering.

All internal walls of the building should be smooth plastered and painted with a water-resistant paint so that they can be washed. Ideally walls should be tiled to about one to one point five metres above ground level. If this is too expensive then tiling should be carried out around sinks and on walls where

food may be splashed.

The bottom of the wall, where it meets the floor, is often forgotten. A right angle joint is difficult to clean and can collect dirt. The concrete floor should be curved up to meet the wall (Figure 6: Some desirable features in a food processing building) and so provide a smooth surface that is easily cleaned. Similarly window ledges should slope so that they do not collect dust, dirt or old cloths that may be left there by workers.

Most manufacturers are aware that windows should be fitted with fly-proof mesh, but they often forget other points through which insects, birds and rodents can enter the processing room or store-room. Important areas are gaps where the roof meets the walls and gaps in the roof. Rats are also able to get into buildings along power lines and these should be fitted with metal discs at least twenty five centimetres in diameter.

In tropical climates, a large overhanging roof shades the walls, making working conditions better and providing a useful area for activities such as bottle washing.

Most types of food processing involve the use of large amounts of water, and floors must be designed so that they drain efficiently. The best way to do this is to slope all floors to a central drainage channel (Fig. 6). The drain should be covered with a removable grating to allow cleaning. Drains are a favourite entry point for pests such as rats and cockroaches and the outlets must be fitted with a removable fine mesh.

All electric power points should be fixed at least one to one point five metres high on the walls to keep them dry. Any 3-phase equipment should be installed by a competent electrician. Although they are

expensive, waterproof power points are preferred in wet areas. Fluorescent tubes provide good lighting for general work but it must be remembered that normal bulbs should be used near to machines with fast moving parts. This is because fluorescent light can cause a rotating machine to appear stationary at certain speeds; an obvious hazard to workers.

Many food processing operations involve heating, often with the production of steam.

Good ventilation is therefore essential and large mesh covered windows, roof vents and ceiling fans should be used. Extraction fans may be required above boiling pans if the heat cannot be removed from the room by other means.

Water quality is essential to quality assurance and food processing requires a good supply of clean, potable water for cleaning equipment, cooling filled containers and sometimes as a food ingredient. In many parts of the world the main water supply is unreliable and the manufacturer must use other methods to overcome water supply problems.

A simple way to do this is to build a double-chambered high level water tank (Figure 7: Double tank water purification system). This allows cloudy water to settle and be treated with chlorine in one chamber of the tank, while the other chamber is being used. Water treatment is described in more detail in Chapter 1.3.

Equipment and layout

Poor equipment layout can be blamed for many quality problems in food factories. In many small factories workers can be seen almost working against each other, colliding and dropping things.

However, good planning and risk assessment can be used to avoid many such errors. The two broad principles to remember are:

- **There should be smooth flow of materials around the processing room, from incoming raw materials to finished products (Figure 8: Layout of equipment in a food processing room).**
- **Cross-contamination should be avoided. It is easy for example, for spray from unprocessed foods to enter a container of product being filled after processing. This results in contamination and wasted food.**

1.3 Sanitation and hygiene

Buildings and equipment

The building and equipment must be kept clean at all times as part of a planned quality assurance programme. A thorough clean-down at the end of the day is essential but this alone is not sufficient. Workers must also be trained to keep equipment clean throughout the day and to remove wastes from the building as they accumulate.

The type and frequency of cleaning depends on the food being processed. The most important point is that the manager identifies all areas of potential hazard, then develops a cleaning plan and makes sure all staff are trained and know their particular responsibilities. Most importantly, the manager should allow adequate time for cleaning down. Too often the final clean-down is carried out in a rush during the last few minutes of the day.

In dry processing, or in processes that use dry powders such as flour, it is essential that all dust is

cleaned from the building, not forgetting high window ledges, old sacks etc. The objective is to prevent any areas collecting dust where insects can breed.

For wet processes, cleaning involves the use of both detergents and sterilants. Detergents remove food residues but do not kill micro-organisms. Sterilants (mainly chlorine) kill microorganisms but do not remove residues. Therefore for good cleaning the residues are first removed with a detergent and the equipment is then treated with a sterilant. A large range of detergents is available for different uses (for example to remove scale or fat). Manufacturers should investigate which types are available locally and consult suppliers to find the best type for their process.

Chlorination

Chlorinated water is needed for cleaning, washing raw materials and as an ingredient in some products. The required level of chlorine depends on the use of the water. Water for cleaning requires a high level of chlorine; up to 200 ppm (parts per million, the normal method of expressing chlorine levels). Water used in a product should contain about 0.5 ppm to avoid giving a chlorine flavour to the product.

There are a number of ways of preparing chlorinated water for use in the processing plant. The simplest way is to use household bleach, which is readily available in most countries. Table 3 shows the dilutions needed to give different chlorine concentrations.

Table 3: Dilution of bleach

Amount of bleach (ml)	Amount of water (litres)	Chlorine concentration (ppm)
1000	250	200

500	250	100
25	250	5
2.5	250	0.5

Alternatively bleaching powder can be used. This is cheap and when fresh, contains 33 % chlorine. The powder does however weaken with time and tins should always be kept sealed when not in use. Bleaching powder is used by making up a 1% chlorine solution (30-40g per litre). This is then diluted for use: for example 6mls in 45 litres of water gives a 1ppm solution.

In cases where a pumped water supply from a well is being used it is common practice to use the action of the pump to automatically dose the water supply with a strong chlorine solution. A typical chlorine dosing installation is shown in Fig. 9 (see Figure 9: A typical chlorine dosing installation), and methods for measuring chlorine levels are described in Chapter 3 (chlorine measurement).

A full discussion of methods of water treatment and chlorination are beyond the scope of this book and further reading is given in Appendix 1.

Although chlorine has the great advantage of killing a wide variety of micro-organisms, it also has several disadvantages: it may corrode equipment, particularly aluminium; it can leave flavour taints if it is not rinsed well with potable water; pure bleach MUST BE HANDLED WITH CARE as it can damage the skin and particularly the eyes, as well as cause breathing difficulties.

In addition water in many rural areas of developing countries may be slightly cloudy. This suspended material can be cleared by allowing the water to stand for a few hours before use. A double chambered

tank combining settling and chlorination can be fitted onto the roof of a building (Fig. 7). The tank should have a sloping bottom and be fitted with drain valves at each end. Both tanks are filled at the end of the day and chlorine solution is added at the required level. By the morning the suspended solids will have settled. In use, water is drawn off from the high level valve and when the tank is almost empty the low level valve is opened to flush out any settled material. The tank is then refilled and the water allowed to settle while the second chamber is used.

Operator hygiene

Operators are a potential source of contamination of foods but to a considerable extent the risk depends on the type of food products. For example, a food that is hot-filled into a bottle, sealed and then heat-treated carries a far smaller risk than a baked meat pie which is handled after it has been cooked. The manager should evaluate the risk and ensure that hygiene procedures are established in the factory and that they are appropriate to the types of products being made. Such measures include the following:

- **All workers should use clean uniforms, shoes and hats that cover the hair.**
- **All workers should scrub their hands and fingernails with unscented soap at the start of each production session. Clean towels or disposable paper towels should be provided.**
- **Workers should be trained to understand the importance of good hygiene. Local public health departments can usually provide training, posters etc. The training will include:**
    - **Hands should always be washed after using the toilet.**
    - **Smoking and spitting should be banned from the processing rooms.**
    - **No food (including the products) should be eaten in the processing room.**

- If affordable, showers should be provided and an area to change clothing.
- Workers who are ill, and especially if suffering from diarrhoea or skin infections should not under any circumstances, be allowed to handle foods.

- Workers with infected cuts, boils or abrasions on their hands should be removed from the production area.

It is very important that workers do not get penalised for having an infection, otherwise they will tend to hide their problem. They should be found other duties; for example, there is always a backlog of cleaning, painting and repairs to be carried out in a production unit. The task of a good manager is to ensure that staff are aware of the risks associated with infections and in this connection wall posters of good and bad practices are very useful. Some of these are available in blank form so that a message can be written in any local language (Appendix 1). A example of a poster is shown in Fig. 10 (see Figure 10: Examples of food hygiene posters).

Cleaning schedules

The overall cleanliness of a food processing unit, however small, can have a major impact on the quality of finished products. For example, particles of food that are trapped in the corner of a tank or in a pipe, can allow the growth of micro-organisms and this can cause massive contamination of products the following day.

Cleaning schedules should be seen as an integral part of an overall quality assurance system and a responsible producer carries out a HACCP analysis of cleaning. Areas of hazard need to be identified, the severity of risk evaluated and cleaning procedures put into place. All areas need attention but some

carry a greater risk than others. For example in a small bakery producing meat pies, all surfaces that contact raw meat should be seen as having the highest risk and they should receive the most stringent attention. Each worker should know their cleaning responsibilities within the overall schedule, The owner must take overall responsibility to ensure that cleaning takes place to the correct standard. It is useful to use cleaning cloths and brushes made of brightly coloured materials as these show up easily if they contaminate foods. It is recommended that a cleaning schedule book is maintained which details the area or item to be cleaned, how, when and who is responsible.

1.4 Regulatory quality control

Almost all countries in the world now have laws governing the production, composition, labelling and safety of processed food and an Agency that is responible for their implementation. In some countries this agency is the Bureau of Standards in others it may be a division of a Ministry such as Agriculture, Health or Trade and Industry. Although the degree to which national food legislation is currently applied varies greatly from country to country, food manufacturers should be aware that the overall trend is to more stringent application, inspection and control by the responsible authority. National food legislation varies considerably in detail from country to country but applies to three broad areas:

- **the plant in which the food is made, its correct design and construction, cleanliness and worker hygiene.**
- **the physical characteristics of the food (including foreign bodies and adulteration), the chemical composition (for example levels of preservatives) and micro-biological quality.**
- **the correct labelling of the product including related aspects such as sell-by date, etc.**

A food manufacturer contravening national food legislation is subject to penalties which can, in

extreme cases, be very severe and involve forced closure of the plant and heavy fines. Manufacturers should be aware that consumers are becoming increasing concerned about food safety and quality issues and are thus more likely to take complaints to the local food control authority. This greatly increases the likelihood of inspection of the premises and products with the resulting risk of penalties.

Food processors should therefore ensure that they know how local legislation applies to their production unit and products. Copies of relevent laws should be obtained and the entire production system should be monitored to ensure that it meets the requirements. Producers that export foods face an even more difficult situation and need obtain copies of relevent food legislation of the importing country as this may vary from their own. In some cases for example, it may be found that a product will need to be reformulated or specially labelled to meet the laws of the importing country.

Unfortunately the authorities charged with the application of food laws are often seen by manufacturers as being threatening and simply "policing" production activities. Ideally food producers should try to use these authorities as advisers. In many cases they will be able to provide useful guidance to avoid a problem developing (for example checking that a new label design meets local requirements prior to spending money on printing).

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Chapter 2 Quality assurance of selected commodities

2.1 Milled products

The process flow chart for selected milled products is shown in Fig. 11 and a summary of the main quality assurance procedures for cereal and oilseed processing is shown in Table 4 (see Table 4: Quality assurance procedures for cereal and oilseed processing). The quality assurance procedures in the table are discussed in more detail in the following Chapter.

Introduction

In this chapter three types of milled products are considered:

- **flour milling**
- **rice milling (or dehulling)**
- **oil milling (or extraction)**

Although the technology differs for each product, there are similarities in the quality assurance procedures that are needed, particularly when considering raw material and process control.

The main quality factors for milled products are the need for correct raw material storage to maintain the characteristic milling qualities and flavour, the absence of moulds or other contaminants and the correct moisture content for processing. During processing, the main quality control measures are concerned with correct operation of mills, dehullers or oil expellers to maximise yields and give the desired quality characteristics in the finished products. These aspects are described in more detail

below, together with information on packaging and storage control for individual products.

2.1.1 Cereals

Introduction

In general cereal grains and flours are considered to have a low risk of causing food poisoning because when properly dried they have a low moisture content which inhibits the growth of food poisoning micro-organisms. However, cereals may be infected with moulds if allowed to become moist and one group in particular gives cause for concern. These are moulds of the Aspergillus family (especially Aspergillus flavus and A. parasiticus) that produce poisons named 'mycotoxins' which cause serious liver damage and in severe cases, death. Although this problem might occur in cereals it is more prevalent in oilseeds and it is therefore discussed in more detail in Chapter 2.1.2.

Cereal grains have four main components: the germ, the starchy interior, an outer bran layer and a protective fibrous husk. The purpose of milling is to separate these various components to produce a range of products with the particular qualities that are required during further processing. For example, when milling wheat to produce flour for bakeries, the customer (the baker) may require a finely milled white flour that contains mostly the starchy material with little or none of the bran, germ or husk. Similarly, in maize milling to make flours for foods such as tortilla, kenkey or nsima, the aim is to separate the starchy material from other components. In rice milling the aim is to remove only the outer husk from the grain and for 'polished' rice, to also remove the bran layer.

All cereals may pass through a long chain of unit operations from harvest to final consumption and sometimes this chain may be very complex and involve a large number of people. An example of such a post-harvest chain is shown in Fig. 11 (see Figure 11: Process Flow diagram for cereal and oilseed milling). There are three main parts to the chain; harvesting and storage, primary processing, after which the grain is still not edible and secondary processing to convert the grain to an edible form.

The main areas of quality assurance and control are:

- **Raw material harvesting.**
- **Post-harvest handling and transport.**
- **Processing.**
- **Product packaging, storage and distribution.**

In this chapter quality assurance procedures are described for the first and second parts of the chain, including milling and storage of flour. It should however be remembered that the milled flours are then processed further to make the finished product that is consumed. There are a very large range of finished products including baked goods, pasta, snackfoods, fermented beverages, pastes and porridges etc. An example of the control needed for this final processing is given in Chapter 2.2 on bakery products.

Raw material harvesting

There is an optimum time for harvesting which depends upon the type of crop, its maturity and local climatic conditions. Details of optimum times for different crops are given in the reference (FAO, 1970) in Appendix 1. The main quality considerations are to harvest the crop after it has been partially dried

by the sun but before there is significant insect infestation.

A common practice that reduces grain quality is to harvest before the grain is sufficiently mature and dry. Farmers may wish to harvest early to obtain the income, repay debts or to avoid theft of the crop. Grains that contain a higher level of moisture deteriorate more quickly because the enzymes in the grain are still active and the moisture supports mould growth and insect damage during storage.

However some grains, particularly maize and paddy that are left in the field after maturity may become repeatedly moist from night-time dew or rain and then repeatedly dried by the sun. This causes the grain to crack and become more likely to be infected with moulds and infested with insects.

Similarly, cracking can occur in very dry, hot regions where moist grains are dried too quickly. This results in bleaching, scorching, discolouration and reduced milling quality. 'Case hardening' can also be a problem. Here the surface of the grain dries and forms a barrier which prevents moisture from leaving the interior of the grain. If such grain is placed in a store, the moisture slowly moves to the surface and results in mould growth and insect infestation.

Where possible the processor should have some control over the way that cereal crops are treated before they arrive at the mill. This can be done by assisting farmers through extension agents who advise on the correct time of harvest if these problems are found to occur. The agent can also advise on the correct use of pesticides to reduce the likelihood of pesticide residues contaminating the harvested crop.

The other two operations that are usually carried out in the field are threshing and winnowing. These may be done by hand or through the use of small machines. The main quality control factors are to use

methods or machines that are appropriate for a particular crop so that the grain is not cracked or broken and to ensure that the separated grain is placed into sacks or boxes to avoid contamination by soil, chaff, stalks etc.

Drying and storage

Correct drying and storage are critical stages in the post harvest system for achieving good quality products. Grains are usually transported to a separate area for further drying and storage. Depending on the climate and the level of investment, drying may be carried out in dryers or in the sun on a large flat surface such as a concrete or hardened earth slab, on mats or plastic sheets or on roofs. It is important that the grain is dried quickly to prevent mould growth, germination, discolouration and insect infestation, but not too quickly as this can result in cracking or case hardening. When grain is dried in the sun on open surfaces there is also significant risk of contamination from birds, dust and animals, as well as wetting from rainfall.

There are considerable quality advantages in using one of the many designs of forced air dryer (for example see Figure 12: A bin dryer for drying cereals) in which the temperature, humidity and airflow are controlled. The grain is dried quickly and uniformly and is less likely to become contaminated by dust, insects or animals. The grain is also stored in different types of silo dryers and therefore requires less handling. However, the higher capital investment and operating costs may make this technology inappropriate for individual small scale farmers; although it may be appropriate for groups of farmers or co-operatives.

There have been many attempts to develop solar dryers which have a lower capital cost and do not require the fuel or power needed by forced air dryers. However, because of the large volume of grain

that is harvested at one time, the success of solar dryers has been limited to date. This is due to the higher capital cost compared to sun drying and the extra labour required to regularly load and unload the dryers. In addition the rate and uniformity of drying may not be higher than sun drying. The main benefit of solar dryers is protection of the crop from contamination and periodic rainfall.

Methods for improved grain storage are widely documented (see Appendix l) and are not discussed in detail in this book. The main factors that relate to quality assurance are as follows:

- The construction of the store should prevent insects, rodents, birds and rainfall from entering.
- The floor should be raised or sealed to prevent moisture entering from the ground.
- If the climate is suitable for storage (if the humidity of the air does not cause the dried grain to lose or gain moisture) there should be a free flow of air through the store. In very humid areas the store should be sealed to prevent the grain absorbing moisture.
- Stores should be inspected to ensure that they are clean before use. All dust, old grains, insects, etc. should be carefully swept out.
- Any grain placed in the store should be completely dried to the correct moisture content (Table 5). Even small amounts of moist grain will respire, cause insect larvae and moulds to grow and create 'hot spots' which will then spread to the bulk of the grain. Moist grain may also begin to germinate causing an increase in the sugar content of the grain and reducing its quality for bakers (see also Chapter 2.2). Methods for measuring the moisture content of grains are described in Chapter 3 (moisture content measurement, grains).

Table 5: Guideline moisture content for safe grain storage

Type of grain	Maximum moisture content (%) for one year's storage at 27C and relative humidity of 70 %
Maize	13.5
Milled rice	13.0
Millet	16.0
Paddy rice	15.0
Sorghum	13.5
Wheat	13.5

Adapted from: FAO, 1970.

- **The air in the store should not undergo large changes in temperature. If this occurs, moisture from the air may condense on the grain to cause localised wetting. This in turn will create hot spots.**
- **The store should be inspected regularly by checking for heating of the grain, smelling for mouldiness and looking for discoloured grains, signs of mould or insects. This will prevent small infestations developing into major problems and losses. If any of these signs are found, the grain should be removed, re-dried, sorted and replaced. A technique termed 'sunning' is useful for dis-infesting grains and is described in the reference in Appendix 1.**

Grain millers or rice polishers frequently buy grain from agents or intermediaries, who in turn purchase from the farmers. The disadvantages of this system are similar to those described in the chapters on fruit products and herbs and spices (Chapters 2.3 and 2.4) and where possible millers should have close

contact with farmers to advise them on the drying and storage conditions that will maintain the required quality in the grain. As with these other products there are a number of ways in which this can be achieved, such as agreements with farmers.

It may be possible for millers to reach agreements with a number of farmers in an area to supply grain of a specified quality. Typically the specification would include details of the variety to be grown, the required moisture content, acceptable levels of infestation or contamination and degree of maturity. The price is guaranteed provided that the quality is met and there may be a part of the agreement that specifies the maximum amount that will be bought.

It may also be possible for the processor to offer both training for the farmers in how to dry and store the crop to maintain the required quality and also to employ a field worker to advise the farmer at harvest time.

Quality assurance in the mill

Hygiene and safety rules for buildings and equipment

Details of the correct construction of buildings and layout of equipment are described in Chapter 1.2. In mills the major hygiene problem arises from flour or bran dust which can collect on ledges and floors unless a proper cleaning programme is implemented. If dust is allowed to collect, it attracts insects which may breed to large numbers and contaminate good quality flour. If dust accumulates above equipment it may become rancid or infested and then fall as large lumps into the product, causing gross contamination. Accumulations of flour or bran dust also attract rats and birds which contaminate grain and stored flour with hairs, feathers and excrete. A cleaning schedule should therefore be implemented

each day by operators who have the responsibility and time to ensure that it is done effectively.

Flour mills and dehullers are potentially dangerous pieces of equipment and safety procedures should be devised and strictly enforced. For example:

- **All belts should be fitted with guards.**
- **Operators should stand clear of mills when they are started up.**
- **Operators should not wear loose or torn clothing that could become caught in moving belts.**
- **Operators should be prevented from putting their hands into feed chutes and an appropriate wooden or cane tool should be provided for unblocking grain 'bridges' in equipment.**
- **No repair or maintenance should be carried out until the mill or dehuller has been isolated from the power supply.**
- **The area around the mill or dehuller should have good lighting (see Chapter 1.2.).**
- **All electrical equipment should be properly earthed. If the mill is not kept clean the combination of a dusty environment and a spark from poorly earthed equipment could result in a dust explosion.**

Raw material inspection

When grain is delivered to the flour or rice mill it should be inspected by taking a sample from the batch. Most often the grain is delivered in sacks to small scale millers and a sample should be taken from the sacks using a 'Thief Sampler' (Fig 34). The sample should be carefully examined for the following quality characteristics:

- **Correct type of grain.**
- **Presence/amount of other seeds.**

- **Presence/amount and type of contaminants such as chaff, soil, dust, insects, rat hairs or excrete etc.**
- **Damaged grains (cracked grains or insect damage).**
- **Moisture content.**
- **Colour of the grains/any discolouration.**
- **Maturity (over-ripe or under-ripe).**
- **Visible mould.**
- **Presence of flour mites.**

Except for moisture determination (Chapter 3: moisture content measurement, grains), these checks may be carried out without specialised quality control equipment. Operators involved in raw material inspection should be fully trained and some form of incentive scheme to reward careful inspection may also be appropriate. The results of the examination and the amount in each batch should be recorded in an Incoming Materials Test Book, noting the number of the batch and the name of the supplier (Fig. 25).

Primary processing

Cleaning

Depending on the outcome of the raw material inspection and the level of contamination that is found, it may be necessary to clean the grain before it is milled. This is necessary for two reasons: to prevent contamination of the finished product and to protect the mill or dehuller from excessive wear or

damage by sand or stones. The cleaning method to be used depends to some extent on the contaminants that are present, but it is usually sufficient to sieve the grain to remove dust, sand, insects, small stones, weed seeds, etc. through a fine mesh and retain chaff, leaves and larger stones on a coarse mesh. The weights of contaminants in each batch should be recorded and the results reported back to the supplier. This evidence may be used to re-negotiate the price paid in cases of serious contamination.

Conditioning

Conditioning of grain before milling is important to ensure the proper separation of the component parts of the grain and give a good yield of flour (or in the case of rice, a good separation of the hulls). A quality control check on moisture content should be made (Chapter 3: moisture content measurement, grains). Grain that is too moist should be redried. If it is too dry a small amount of water is mixed in and the grain is stored for 1224 hours and tested again for moisture content. Parboiling of rice and subsequent drying has beneficial effects on both the efficiency of dehulling and the quality of rice after storage. It helps to prevent rice grains cracking and also increases their resistance to insect attack. The main quality control points are the time of parboiling and the rate of drying.

Blending

The grain supplied to rural millers is in most cases, milled to a single flour which is then sold. However, if millers are supplying bakers or other secondary processors, there may be a demand for flours that have specific properties (see Chapter 2.2) or for composite flours. It is then necessary to blend different grains before milling. The quality assurance aspects of blending are mostly concerned with control and identification of stocks, so that the miller knows where different grains are stored and with

accurate weighing and adequate mixing of the raw materials to achieve a uniform blend for each batch.

Milling

The most appropriate types of mill for different cereal products depend on a number of factors, including the type of cereal being milled, the degree of milling (or fineness) of flour required, power consumption, required throughput, the capital that is available for investment, the availability of spare parts and maintenance/repair facilities. Similar considerations apply when selecting a dehuller. There is a very large range of milling equipment available but there is insufficient space in a book of this type to describe the different options in detail. However mills that are commonly used by small scale millers for all types of cereals include plate mills, stone mills and hammer mills. Roller mills for wheat are usually too expensive for small scale processors and are confined to large scale centralised mills. Rubber roller dehullers are commonly used for rice hulling.

Once a mill or dehuller has been set up correctly, following the manufacturer's guidelines, it should be regularly checked as part of a routine quality assurance programme. This is important because the grinding surfaces wear over a period of time and require adjustment or replacement. For example the grinding plates of a plate mill can last for 1-3 months before replacement, but if there is significant contamination of the grain by sand, the replacement time can be reduced to one or two weeks. If the plates are incorrectly adjusted the quality of the flour, as indicated by its fineness, becomes variable. Similarly, the efficiency of dehullers is reduced if the gap between the rollers is not regularly checked and adjusted. The miller should therefore check the adjustment of the mill or dehuller for every batch of grain.

Other moving parts require a daily check to ensure that they have not become loose or out of

adjustment. A metal bolt falling into a mill can cause serious damage to the grinding surfaces and metal filings from worn parts cause contamination of the product. The same considerations apply to the routine checks on dehullers.

A further quality control check is to measure the range of particle sizes in the flour which provides information on the degree of milling and the efficiency of the mill. Particle size measurement is described in Chapter 3 (sieving tests). Although the sieves and shaking machine that are used for this check are relatively expensive, the equipment provides valuable information to those millers who produce specialist white flours. The equipment would not normally be recommended for small scale rural millers.

Sieving

In rural areas it is common for whole-meal flours to be sold by millers and in this case there is no separation of the components of the grain after milling. Typically maize, sorghum, millet and whole-meal wheat flours are produced by dehulling the grain, milling to a flour and then using the flour directly to make the finished products. In other cases there is a demand for a whiter flour in which the majority of the bran and germ is removed to leave predominantly starchy material (for example maize, wheat and rice flours). This separation is achieved by sieving the freshly milled flour through mesh screens, often fitted with brushes to increase the throughput of the screens.

A quality control check at this stage of the process is to examine the sieved flour for bristles that may have fallen from the brushes. The presence of a bristle acts as an early warning that the brushes may need replacement. In addition checks should be made to ensure that the flour does not contain insect eggs, insect parts or other types of contamination. Larger contaminants are separated by a sieve test

(Chapter 3: sieving tests) and small contaminants such as insect parts can be isolated using a 'filth test' (Chapter 3: sieving tests, filth test). Flour mites are a particular problem for two reasons: mite excrete causes flour to have a minty smell and make it unusable; and mite hairs can damage the health of operators by causing skin inflammation and lung disorders. If insect parts or mites are found in flour the source should be traced back to either incoming raw materials or infestation in the flour mill and corrective measures should be taken (Chapter 3: insect infestation).

Records should be kept of the amount of raw material milled, batch numbers and the product code numbers that are given to each sack of flour produced. This allows the processor to trace any subsequent faults in a batch of product back to the process and the raw materials used.

Packaging

Jute or hessian sacks are commonly used to package flour or dehulled grain but multi-layer paper and woven polypropylene sacks are increasingly being used. There are a few visual quality checks that are done on sacks, mainly to ensure that they are properly cleaned, they are not contaminated with other materials and they do not have holes or split seams.

Flours should be carefully filled to ensure that dust is minimised and that the amount in the sack is the same as the net weight described on the label. In most countries it is an offence in law to sell an under-weight product and over-filling means that the company is giving away product at a loss. A large capacity scale (eg 100kg) may be used if the product is filled by hand. Alternatively semi-automatic bagging machines, in which a weighed amount of product is discharged into an open sack, may be cost-effective for larger scale mills. Sacks are then sealed by either tying the neck with rope or by stitching the top of the sack using a stitching machine (Figure 13: An electric sack stitcher).

Storage and distribution

Once the cereal or flour has been sealed into a sack the risks of contamination by insects, dust and micro-organisms are reduced but not eliminated. Incorrect storage conditions such as exposure to sunlight, heat and water, can all result in spoilage. This is particularly important because the expenditure that has already been made during processing makes losses at this stage very damaging financially.

Sacks of flour or dehulled cereals should be stored on pallets to keep them off the floor of the store-room (see Chapter 1.2). The sacks should be carefully stacked (Figure 14: Examples of good and bad stacking of flour sacks) as a poorly stacked block could collapse and injure operators. The store-room should be cool and dark with a good ventilation to maintain a flow of air. In particular windows should be screened against insects and the structure of the roof and walls should prevent rats and birds from gaining entry. The comments above on cleaning schedules should also include storerooms.

It is important to develop a management system to monitor which products are in the store, to control stock rotation and record their destination for delivery. This is particularly important when a range of products is made as slower-selling items may be hidden at the back of a store and spoil. Simple records (Fig. 31) should be kept by storekeepers to show which products and materials are transferred into and out of the store-rooms.

Where a miller is responsible for delivery of products to other processors, the delivery vehicle should be included in the cleaning schedule described above to ensure that products arrive at the processors in a clean and uncontaminated condition. In most countries the risks of dust, rainfall and contamination by birds and insects require the use of a covered delivery vehicle. Storage of flour by secondary

processors is described in Chapter 2.2.

Go To Next Page

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

2.1.2 Oilseeds

Contents - Previous - Next

Edible oils are extracted from a wide range of raw materials. Common types include coconut, oil palm, sunflower, groundnut and mustard seeds. The process of oil extraction is often referred to as oil milling and a range of technical options are used from very simple hot water extraction, manual screw presses to large scale solvent extraction. The term oil milling is however generally connected with the use of mechanical oil expellers, a typical example being shown in Fig. 15 (see Figure 15: Small continuous oil expeller).

Cooking oils are considered as low risk products. Their very low moisture content and the heat applied during processing means that microbiological hazards are minimized. A major risk to consumers however can arise from toxins that are produced by moulds that attack oilseeds in store. These are known as mycotoxins and are produced by microorganisms to which the Aspergillus flavus species belongs. Aflatoxin producing moulds can grow on raw material that has been inadequately dried or has

absorbed moisture in storage. It is particularly associated with groundnuts although it has been detected in other products. Although chemical tests for aflatoxins are commonly used, the equipment and skills required put them beyond the capacity of small rural oil processors. Fortunately the presence of aflatoxin producing moulds is usually evident due to the presence of stained, darkened and discoloured seeds.

The first step in developing a quality assurance system when producing edible oils, is to set a system in place that ensures that incoming raw material has been properly dried and shows no sign of mould growth thus minimising a consumer hazard. It should be noted that aflatoxins, if present, tend to be concentrated in the oil-cake that remains after oil extraction rather than in the oil. Samples from a selected number of bags of seed should be taken using a thief sampler (Fig. 34) and wherever possible, examined prior to purchase of seed. In some cases it may be possible to purchase raw materials from a large supplier or para-statal body that has efficient drying and storage systems. Oilseed stocks held by the miller should be stored in a well-ventilated store, off the ground and protected from birds, insects and rodents.

Some oilseeds, for example sunflower, groundnuts and coconuts, require de-husking prior to oil extraction. Others, such as mustard seed, require no pre-treatment.

Prior to oil extraction, larger oilseeds are milled and then in most cases heated in a scorcher or cooker. This treatment breaks oil-bearing cells and assists in the release of oil as the material passes through the expeller. In the expeller, oil is pressed out and flows from the cage and the fibrous residue or cake exits from the expeller 'throat'.

This crude oil contains some moisture, natural flavourings and colours, dirt, vitamins and natural gums.

It is not acceptable for direct use and has to be refined, or cleaned, prior to sale. The extent of refining required, depends upon the type of oil being extracted and the intended market. From the quality point of view it should not be assumed that customers prefer the typical bland, crystal clear oil of the type that is manufactured by very large oil mills. In fact the reverse may be true; for example, many consumers prefer a coconut oil that tastes of coconut and has a slightly rancid flavour.

As part of the total quality assurance system, the miller should thus investigate the consumers' preferred quality requirements and carry out refining to meet these demands. Most small rural millers limit refining to clearing and filtering, or sell the crude oil to a larger processor for more sophisticated refining.

In larger companies, a wide range of refining methods may be applied such as filtering, neutralisation, winterising, bleaching, deodourisation and de-gumming. Those used depend on the type of oil to be processed and the market specification.

Typically in a small mill the crude oil is allowed to stand in large, closed drums for a few days, during which time the majority of suspended matter settles. The cleared oil is then carefully removed by syphoning or decanting. Final clarification is achieved by passing the oil through a fine filter cloth (Figure 16: A simple oil filter).

The main quality tests that need to be applied to oils are for an unpleasant flavour caused by rancidity and the presence of free fatty acids. The rate of rancidity development is speeded up by light, heat, moisture in the oil, moulds, enzymes and some types of metals, particularly copper and iron. For a long shelf life, oils should be heated to remove any moisture and destroy enzymes and micro-organisms. It should then be stored in sealed airtight tins or bottles, protected from the light and in a cool place.

Although chemical tests are available, the equipment is expensive and an experienced miller can simply control the process by the taste and odour of the oil. The presence of higher than normal levels of rancidity and free fatty acids can often be traced to stale raw materials. Millers should therefore check for such faults in their stocks by taste and smell.

2.2 Baked products

Summary

Bread production using the bulk fermentation method is used as an example of a common baked product in the process flow diagram (Figure 17: Bakery process flow diagram). The accompanying table (Table 10) describes the process steps involved and the main process control points. These are then analysed and discussed in relation to developing a quality assurance system in a small bakery in the following chapter.

Table 6: Process flow chart for the production of bread

Introduction

Baking is a long established traditional process and the basic principle of cooking by dry heat in an oven has changed little with time. Traditionally the dough was heated over open fires and hot stones. This progressed to ovens of various shapes and sizes and simple static ovens have been designed and used successfully at village level in many countries (Figure 18: A simple beehive oven). Heat may be derived from a variety of energy sources, ranging from burning coconut husks or camel dung, to heating by electricity or gas.

Baking involves heating a dough or batter in an oven to produce the shape and colour of the crust and to set the internal structure. The baker can control and modify the process to produce a wide variety of products such as buns, biscuits and cakes with different shapes, colours, flavours and sizes (Figure 19: Examples of baked products).

Baked products may be unleavened, or leavened (raised) by yeast, by chemicals, by air or water vapour. The action of the yeast in the fermentation stage may be replaced by chemicals or by mechanical mixing for some products.

Customers expect bread to have an adequate volume, an attractive shape and colour, a crumb that is finely and evenly distributed and is soft enough to chew but firm enough to slice. These quality characteristics can only be achieved through a combination of careful selection of ingredients and control of the manufacturing process. These customer-needs must be documented and agreed, as this will enable the producer to select the ingredients and define the control points within the process. Control of the process must occur during all stages, from selection of the ingredients and packaging materials through to delivery of the finished product and labelling information.

Raw materials and their testing

In contrast to fruits, herbs and spices, where raw materials may come from many small scale growers the ingredients used in breadmaking such as flour, fats, salt and yeast, are normally supplied by large scale producers. Many small bakers are therefore faced with problems of an assured supply when their custom may be of little importance to the supplier. Small companies may be better advised to co-operate with other small bakers and as a group, purchase and store certain raw materials in bulk. On receiving the raw materials small scale bakers may be faced with problems of controlling their quality

with only limited facilities for testing. The correct choice and specification of the main raw materials for baked products is essential to ensure good quality products.

Flour provides the major functional ingredients (starch and protein) which give strength and structure to baked products. Starch has a number of roles in baked products: in bread it produces sugars for yeasts to ferment and gives a framework for the gluten to bond to.

When starch is gelatinised by heat during baking it provides a rigid structure to the finished product. The characteristics of the flour can be controlled by the blend of wheat grains used in flour manufacture or by variations in milling techniques (see also Chapter 2.1).

Small producers do not normally have facilities for flour analysis and must rely on the information supplied by the miller. However useful information can be obtained from simple tests which are described in detail in Chapter 3 (flour infestation, gluten measurement, sieving tests, filth test, water absorption measurement and moisture content).

It is important that the baker buys the correct type of flour. For breadmaking it should be 'strong' (that is, made from hard wheats having a medium protein content), have high protein and water absorption levels and a good colour. For other products 'weak' soft wheat flours are normally used. These are lower in gluten and are therefore weaker (the dough extends more) than hard wheats (Figure 20: Assessing gluten quality, weak flour on left, strong flour on right).

Gluten is the protein which gives the unique elastic properties to bread dough and some other baked products. It can be measured by simply washing out the starch from a small ball of dough under running water and the remaining gluten proteins will be left. The quantity can be measured by removing excess

water and weighing. The quality can be assessed by pulling the gluten piece apart and noting how much it stretches and its breaking point (Chapter 3: gluten measurement). This is a quick test which with experience, provides much useful information to the baker.

Water absorption should be consistent to allow production of a uniform finished product. Bakers should know the capability of the flour to absorb water and adjust the process accordingly - too much absorbed water can give a sticky dough and too little can produce a tough, poorly risen product.

A good quality bread flour absorbs water to 60-65% of the flour weight whereas a biscuit flour may hold 55 %. A simple test is to measure how much water by weight can be absorbed by 100g flour to make an extensible dough (Chapter 3: water absorption measurement).

Starch gelatinisation is the swelling of starch due to heat and moisture and this begins when the temperature rises above 56C for wheat starch. With further heating there is a marked increase in viscosity. At very high temperatures the starch granules burst and the viscosity falls.

The baker may control the nature of the starch in different baked products. For example the starch can be totally broken down, as in wafer biscuits, there can be no breakdown as in shortbread biscuits, or there can be a range of swollen and dispersed starches as in bread. This range of products is achieved by adding ingredients which prevent starch breakdown, by preventing the starch from absorbing water or by adding insufficient water for the starch to swell.

Enzymes present in the flour can attack the starch to produce the necessary sugars for fermentation. However, if the grain has germinated before harvest, an excess of these enzymes can cause problems to the baker by producing too much sugar and giving a sticky dough. A common test that is used for

flour quality is based on gelatinisation and is named the 'falling number' test. The viscosity of gelatinised flour is assessed by counting the number of seconds that a steel plunger takes to drop through a standard gelatinised solution. This number is used to decide whether the enzyme activity is in excess or insufficient and allows the baker to adjust the recipe. A simple modification of the test is described in Chapter 3 (starch gelatinisation).

Incoming flour should have a moisture content of not more than 14% to reduce the risk that moulds, insect infestation and rancidity do not develop during storage (see also Chapter 2.1). Samples should be taken from each batch and tested for moisture using accurate scales and an oven (Chapter 3: moisture content measurement, grains)

Yeast acts on natural sugars in the flour to produce carbon dioxide gas which raises the dough. The level of yeast used is normally 1% of flour weight for a 2 to 3 hour fermentation process. The activity of yeast is crucial to a successful fermentation. The baker must ensure that the yeast is active (alive) and is stored in a cool dry place.

A simple method to test yeast activity involves placing a standard ball of dough in water and timing how long it takes to float to the surface. This is related to the yeast activity by assessing gas production or the power of the yeast to inflate the dough (Chapter 3: yeast activity).

Salt gives flavour, strengthens the gluten, controls the action of yeast and therefore controls the loaf volume. Traditionally salt is added between 1.8% and 2.2% of flour weight and if the salt is above this level the taste of the bread is adversely affected. Salt generally requires little testing.

Fat is an optional ingredient in bread but can improve the appearance of the crumb and contribute to

product flavour and the ability of the dough to retain gas. Fat also improves the keeping quality, softness, moistness and contributes to the texture of the bread. The melting temperature of the fat must be above the temperature of the dough otherwise a sticky dough will be produced.

The main problem encountered with fat is rancidity which can best be detected by smell and taste. Any rancid fat should be rejected. The dough temperature and the melting point of the fat can each be checked using a thermometer.

Sugars are normally present in bread flour at a level of 1-2% and these are acted upon by yeast during the early stages of fermentation. Later the action of enzymes in the flour releases further sugar for gas production. Extra sugar may be added to increase gas production, to improve the crust colour and to sweeten the bread. The main quality problem with sugar is the presence of dirt which can be checked by dissolving a quantity of the sugar in hot water and allowing any dirt to settle.

Storage of ingredients

Flour is normally delivered and stored in hessian or jute sacks, although woven polypropylene is becoming more commonly used. The sack material provides some protection against dust, insects and birds but offers little protection against rodents or a humid atmosphere. It is therefore important that the conditions in the store-room are suitable for the correct storage of flour.

The main reasons for spoilage of flour are an increase in its moisture content which can lead to mould growth, development of rancidity over a period of time and attack by insects, birds and rodents. It is a common sight to see sacks piled on the floor of a store-room or even in a corner of the bakery. Under these conditions the flour can absorb moisture from the floor or from a humid environment and it is

easily attacked by pests.

Details of correct construction and use of food processing buildings are described in Chapter 1.3 and in particular relation to bakery store-rooms the following points should be emphasised:

- **Store flour on pallets away from walls to prevent moisture pick-up and mould growth.**
- **Use stock in strict rotation to prevent development of rancidity and insect infestation.**
- **Ensure that the store is dark and cool without temperature fluctuations.**
- **Ensure that the room is sealed against insects, birds and rodents.**
- **Clean the store each day to prevent dust accumulating as this provides a breeding ground for insects.**
- **If affordable an insect electrocutor should be placed in the store.**

Figure 21: A well managed flour store

Before use, the flour should be checked by workers to ensure that it is free of insects and moulds and that it does not have a rancid smell. Simple tests for insects are described in Chapter 3 (flour infestation, sieving tests and filth test).

Sugar and salt are also delivered and stored in sacks and require the same storage conditions as flour. In particular these ingredients can pick up moisture from the atmosphere and the store-room temperature and humidity should not be allowed to fluctuate.

Fats and oils are usually delivered and stored in tins which protect the oil from air and the development of rancidity. Provided the tins are kept sealed until they are used and the store is reasonably cool,

there should be few storage problems. If the oil is stored in any other containers rancidity can quickly develop. As heat accelerates the development of rancidity cool storage areas should be used. Solid shortenings (fats) are often supplied in a simple paper or plastic wrapping which offers little protection against rodents, insects or birds. In addition, the fat can rapidly develop rancidity if it is exposed to heat or sunlight. As expensive ingredients fats and shortenings should therefore be very carefully stored. If available a refrigerator is ideal. They should also be used as quickly as possible and strict stock rotation should be enforced.

Good quality water is required to form the dough and wash equipment. Details of how to ensure that potable water is available are described in Chapter 1.

Manufacture of bread

The manufacture of bread has four main stages: the first involves mixing the ingredients to form a dough, at the same time entrapping air. In the second stage the gluten structure develops and the yeast acts on damaged starch granules to release sugars. After dividing and moulding, the proving stage allows gas produced by the yeast action to inflate and expand the dough. Finally the inflated structure is baked and set in the oven.

In this chapter the traditional or 'bulk fermentation' method of bread production is described but mechanical mixing, chemical additives, or a combination of both may be used to shorten the dough development time and produce a more consistent product. Details of such chemical and mechanical methods are given in references in Appendix 1.

Process control

The baker can determine the type and quality of the finished product by careful attention to the main process control points which have been summarised in Table 6 at the beginning of this section. They involve accurate weighing, temperature and humidity control, timing and handling procedures.

This systematic approach to quality control and quality assurance requires the baker to understand and modify the recipe or the process to suit natural variations in raw material quality.

Care and maintenance of weighing scales, thermometers and timers are essential for consistent and cost effective production. Quality checks are useful indicators of baking performance and play a significant role in assessing the quality of raw materials. Baking tests are important to modify recipes or processes or when evaluating a new supply of important raw materials. They are normally used to compare new raw materials (for example, fat, sugar and yeast) with a satisfactory flour that provides a good quality product. It is important that the recipe formulation and process control should be carefully standardised to achieve meaningful results from test baking. The products from test bakes can be assessed using a score sheet (see Appendix 2).

Packaging, storage and distribution of finished products

Baked products are packaged to protect them from contamination or deterioration due to moisture loss or pick-up and to enhance their presentation. Plastic film may be used but often baked goods can be wrapped in paper as they are expected to have only a short shelf life. Protection against crushing or dropping can be achieved by packing in cardboard boxes or loading onto trays for transport.

Most baked goods have a dry outer crust which inhibits contamination by microorganisms. However products such as cakes with cream fillings or pies that contain meat, fish or vegetables are a potential

hazard to consumers if not packaged, stored and handled correctly. The danger zone for microbial growth is 5C to 63C and products should therefore be stored below 5C or above 63C. Storage refrigerators for creamed goods must be properly maintained at the correct temperature. The time that the products spend in the temperature danger zone during preparation and cooling must be minimised by proper handling and effective cooling. Problems can also occur if warm bread is packed into plastic bags. Condensation can occur which encourages mould growth on the bread surface. Bread should thus be cool before packing. Stores used for baked products should be cool, dry, regularly cleaned and protected against insects and rodents.

Safe storage and good stock rotation are helped by the use of mobile racks or steel shelving on adjustable supports, which are easy to inspect. Slotted trays made of high density polyethylene are easily cleaned and stacked and they can store a variety of different baked items. For ingredients, mobile storage bins made of plastic or stainless steel, can be wheeled to the point of use.

Undisturbed stock encourages rodent and insect infestation. The correct rotation of stock is necessary to maximise profits and prevent unnecessary wastage and contamination of materials. Daily checks should be made on short shelf-life products and weekly checks made on other products or raw materials in the store. The maintenance of correct stock levels by using the 'first in first out' (FIFO) system is good management practice. Stock rotation is easier with date coding but some products do not require a sell-by date and in these cases retailers should adopt their own code to identify the date of delivery. Colour codes have been successfully used (eg blue for Monday, red for Tuesday).

Hazards associated with baked products

Baked products are rarely involved in food poisoning incidents because the heat during baking kills

contaminating micro-organisms and reduces their numbers to safe levels. Stock control errors generally become obvious with staleness and mouldiness becoming quickly evident. Bread and most baked goods are not therefore classified as high risk foods. However, some of the fillings that are used in cakes, pies and biscuits such as cream, meat or fish pastes and vegetables are of high risk if they are not properly processed and stored. Appropriate care and attention to supplier assurance, good handling, temperature control, and cleaning are therefore essential with these products.

The time and temperature required to adequately cook a product vary with the product type, the types of micro-organisms present and the size of the food pieces. The baker must monitor the baking temperature to ensure that such micro-organisms are destroyed and the bread is not too moist as this will encourage bacterial growth. A common bacterial problem associated with bread is known as "rope", which results in the bread having a stringy consistency. The micro-organism that causes rope, Bacillus subtillis. has spores that can withstand the high temperatures of baking. The initial spoilage results in a fruity odour in the product but later, brown discoloured patches develop and the bread becomes sticky. It is this sticky material that can be pulled into strings or "rope" (Figure 22: "Rope" in bread). Consumption of the contaminated bread can cause illness.

Rope micro-organisms can be present in flour, water, salt and yeast. They can be controlled by specifying good quality ingredients and ensuring good handling practices in the supplier chain. This can be done by:

- **Minimising contamination.**
- **Not using defective or dirty equipment.**
- **Using disposable gloves and cloths.**
- **Only handling ingredients when essential.**

- **Strict personal hygiene and clean work clothes.**
- **Keeping food covered at all times to prevent pests coming into contact with food.**
- **Using rodent-proof containers.**
- **Using correct cleaning procedures and sanitisers.**
- **Not handling contact areas of equipment (for example knife blades).**
- **Good housekeeping, especially control of waste materials and dust and keeping food and equipment off the floor.**
- **Using separate washbasins for hands and equipment.**

Another method of preventing rope is to add sodium propionate or more recently, acetic acid (vinegar) to the dough. Acetic acid may be added at 0.1 to 0.15 % of the flour weight. The higher level is normally used when rope problems are present or when the weather is very hot. Cleaning schedules and procedures should target important areas including equipment, water tanks, contact surfaces and attention to personal hygiene.

The application of HACCP principles to the manufacture of bread shows that the main hazards are physical contaminants, mould or rope. A small company may consist of the manager and a supervisor and they should identify the source of these contaminants and then implement methods which eliminate or prevent them. Contaminants identified in the incoming raw materials may be controlled by agreements with suppliers and sieving of dry ingredients. Sources of metal or wood contamination within a process can be identified and controlled. For example there should be no wood in contact with food products and machines should be checked before and after use to ensure that no parts are missing.

Go To Next Page

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

2.3 Fruit products

Contents - Previous - Next

The process flow chart for selected fruit products is shown in Fig. 23 (see Figure 23: Process flow diagram for fruit products) and a summary of the main quality assurance procedures for fruit processing is shown in Table 7 (see Table 7: Quality assurance procedures for fruit processing) below. The quality assurance procedures in the table are discussed in more detail in the following chapter.

Processing of fruits

Heat (1) = Pasteurization
Heat (2) = Concentration

Introduction

Fruit products are commonly produced by small scale rural producers as the technologies are relatively simple and producers are often close to the source of supply. The main quality factors associated with fruit products are the characteristic flavour and colour of the fruit, the absence of contamination, and in some products, a characteristic texture. However few quality characteristics of fruit products can be

measured objectively and fewer still can be measured by machines. Therefore reliance should be placed on subjective assessment by operators and the more operators that examine the raw materials, ingredients, process and product, the greater will be the level of control. The importance of proper staff training and involvement in production, as stressed in Chapter 1.1, are particularly important in fruit processing.

In general fruits and fruit products are considered to have a low risk of causing food poisoning. This is because they contain natural acids which prevent the growth of food poisoning bacteria. For fruits having a medium acid level, citric acid is usually added to bring the pH down below 4.5. Processing, either by drying, heating (such as pasteurisation of juices) or by adding salt, (in pickles), or high levels of sugar (in jams and crystallised fruits), also reduces the risk of contaminating bacteria.

However fruits can be infected with moulds and yeasts and processors should use good quality raw materials and have strict control over hygiene and handling. The main areas for the application of quality assurance and control are:

- **Raw material harvesting and transport**
- **Processing**
- **Product packaging, storage and distribution**

Raw material harvesting, transport and inspection

There are a number of specific problems with fruits that are not found to the same extent with other foods:

- **With a few exceptions fruits ripen during a short harvest season and this means that processors must buy sufficient raw materials for one year in a short space of time. The pressures are therefore high to collect and process a large amount of fruit quickly. The large expense involved in purchasing all raw materials in a short period can also cause difficulties with the business cash-flow.**
- **Fruits must be harvested at the correct stage of maturity to give the best flavour and colour in the finished products.**
- **Fruits ripen quickly in tropical climates and they soften when ripe. This increases the risk of bruising and splitting if they are not handled correctly.**
- **Damage to fruits through poor handling allows moulds and yeasts to grow rapidly in the damaged areas and this dramatically accelerates spoilage rates.**
- **Damage to a few fruits can quickly lead to infection of others and the loss of a whole batch may result. It is estimated that poor handling after harvest results in the loss of 5080% of some types of fruit such as mango and tomato.**

A further problem facing manufacturers in many developing countries is the large number of different varieties of a particular fruit. It is common for example to see four or five different varieties of mango or banana on sale in local markets, but not all varieties are suitable for processing and many have very different tastes. For a processor to be able to make a uniform product, there must be either control over the variety of fruit that is used, or a standard system of blending raw materials to give a consistent product.

Unfortunately this is not always easy to achieve as fruits are often grown in small quantities by individual farmers. It is usually the case that farmers have a few fruit trees on their land to provide a

little extra income in addition to their main crops and to provide shade around their houses or in the fields. Planted orchards or fruit estates in which the variety is selected and cultivation is managed, are the exception. For the manufacturer there is therefore a problem in obtaining enough fruit of the required variety and quality to allow proper production planning and quality assurance of the raw materials. Some of the options that are available to processors are described below.

Buying fruit from markets

Many small scale producers buy fruits from local markets, particularly when they first start a business. Because fruits are often seen as a low-value food, they are handled without care by farmers and traders. They may be piled into heaps on the ground and then thrown into trucks for transportation, without protective crates or boxes.

The system of payment and distribution of fruits frequently causes problems of poor quality and high levels of spoilage losses. In some countries, traders or 'middlemen' tour a farming area and buy all of the fruit that a farmer produces, regardless of its condition. They then transport the fruits to central markets where it is sorted into different quality grades. Higher quality goes to more expensive retail markets and lower quality to cheaper markets. Because the system of payment to traders does not rely on supplying high quality fruit there is little incentive to protect the fruit during transport. In fact the use of fruit boxes adds weight to a load and reduces the space available for carrying larger quantities. There is also little incentive to return empty boxes to farmers as the carriers do not receive payment for this.

Similarly, the farmers have little control over the treatment of their crops by traders and because the traders are willing to buy all of the crop and often offer informal credit and loans to farmers, the

farmers may become indebted and are unable or unwilling to change the system by which they sell their crops.

For the processor to achieve higher quality raw materials it is better to avoid buying from markets with their attendant problems of variable quality and uncontrolled prices. There is a limited range of other options, each with its associated costs and benefits.

Agreements with farmers

To avoid the variations in quality and price that are found in markets, it may be possible for processors to reach agreements with a number of farmers in an area to supply fruit of a specified variety and quality. Typically the specifications would include details of the variety to be grown, the degree of ripeness (often described by the colour or firmness of the fruit) and the minimum size of each fruit. The price is guaranteed provided that the quality is met and there may be a part of the agreement that specifies the maximum amount that will be bought. In this type of agreement it may also be possible for the processor to both offer training to the farmers in how to achieve the required quality and to employ a field worker to advise the farmer throughout the growing season.

The advantages to the processor are a greater control over the variety and quality of the raw materials, some control over the amounts supplied and an indication of likely raw material costs. This is helpful in production planning and maintaining a positive cash-flow in the business.

The advantage to the farmer is less clear if traders normally buy all of the crop. If however the farmer usually sells directly in local markets, the security of having agreed sales to the processor at a known price may be an incentive. However, it is difficult to persuade farmers to reduce their sales to traders.

The local power of traders may include a refusal to offer loans to farmers, a threat not to buy the crop again if sales are made directly to processors and possible indebtedness by farmers who may be threatened to repay loans immediately.

Contract farming

This approach has been tried in many countries with varying degrees of success. A processor specifies the types of fruit to be grown, often supplying seeds or grafting new varieties onto existing trees and sometimes supplying all other inputs including fertilizer, pesticides and even labour. In effect the farmer is simply being paid for the use of his or her land.

The price paid for the crop is often set between the mid-season lowest point and the end-of-season high point. The advantages to the producer are an assured supply of the required variety at a cost that is known in advance and can therefore be planned into the production costs. For the farmer there is a guaranteed sale of the crop with a known income. The risks to the processor are that the farmer will sell on the open market once the price rises above that agreed in advance, resulting in less fruit available than planned.

There is also a higher risk and more planning involved when processors supply all of the inputs to farmers.

The risk to the farmer is that the processor will not honour the agreement or payment will be delayed. For such a system to operate effectively and benefit both farmers and processors, a level of trust has to be built up by honest dealing over several seasons.

Manufacturer's farms (Nucleus farming)

Here a processor buys land and hires labour to produce the fruits required for the range of products being made. In effect the farm becomes another department of the factory and is totally within the control of the processor. Because of the higher costs associated with this option it is usually only attempted by larger companies and is therefore beyond the scope of this book.

Good practice in harvesting and transporting fruits

Fruits are usually harvested by cutting them from the tree or plant, by hand picking or by mechanical systems in large plantations. It is important to leave the stem of the fruit in place and not to pull it out when harvesting. This reduces the risk of moulds and yeasts infecting the fruit through the open hole. Where it is not possible to hand pick fruit (for example from tall trees) a net or cloth should be stretched below the tree to catch the fruit as it is shaken down and prevent it being damaged by hitting the ground.

Some fruits such as wood-apple and orange have a strong outer skin which resists puncturing, but most have a thinner skin that is easily damaged by poor handling, especially when fruits are ripe and soft. The following suggestions can result in improved fruit quality:

- **People handling fruits should be encouraged to cut their fingernails to prevent them puncturing the fruits.**
- **Fruits should be carried and not thrown. They should be placed into boxes or crates when being moved and not dragged along the ground in sacks.**
- **They should be stored in crates while awaiting transport and not heaped into piles.**

- **Boxes or crates should not be over-filled as this increases the risk of fruit falling out when they are moved and also crushes the fruit if boxes are stacked.**
- **If possible fruits should be washed in cool water immediately after harvest to remove some of the 'field heat'. Where this is not possible the fruits should be stored in a cool place away from sunlight while awaiting transport. If a store is not available a good alternative is to cover the crates of fruit with wet sacking or cloth.**
- **Fruits should be packed into stackable boxes (Figure 24: A well-designed box for transporting fruit) to reduce damage from crushing and bruising during transport. The manufacture of such boxes can also form an important rural industry.**
- **Any obviously infected or damaged fruit should be removed as it would rapidly cause spoilage of surrounding fruit during transport to the processing unit.**

Fruits are easily damaged by vibration and bumping when they are carried on trucks, especially on unmade rural roads. Where possible transport by train or by riverboat is a better option for protecting fruit because of the reduced vibration. Although this is often not available, there are many examples in the authors' experience where this type of transport exists but has never been considered or evaluated.

Raw material inspection

Once the fruit has been transported to the processing unit it is within the control of the manufacturer and more systematic quality assurance procedures can be adopted. As resources for quality assurance are usually limited they should be focused on the parts of the process that are most effective in ensuring that the products meet customer specifications. The HACCP approach should be used as a means of achieving maximum results from the resources available for quality control. Examples include

regular monitoring of the cleanliness of the production area and checking to ensure that there is no animal or insect infestation, maintaining good operator hygiene by regular inspection and training, making sure that wastes are disposed of properly and regularly.

When raw materials arrive each batch should be recorded in an Incoming Materials Test Book, noting the number of the batch, the name of the supplier and useful observations (Figure 25: Incoming materials test book). This information should also be recorded for other ingredients and packaging materials used in the process.

The first series of checks are made on the raw materials as they arrive at the processing unit. These usually involve spreading the fruits on sorting tables and inspecting them for quality and suitability for processing. Maturity of raw materials is usually assessed by looking at the fruit or sometimes by handling them as there are few objective tests that can be applied to incoming fruit in small processing plants. Similarly, other ingredients should be checked to make sure that they are of the right type and have not been adulterated. Packaging should be inspected on arrival to make sure that it is the correct type and is not damaged m any way.

Checks on incoming fruit should include the following:

- **Colour.**
- **Size.**
- **Maturity (over-ripe or under-ripe).**
- **Visible mould or rots.**
- **Serious bruising or cuts.**
- **Presence of foreign material.**

- **Percentage of rejects.**

Any fruits that do not meet the required standard are removed together with foreign matter such as leaves, stones, etc. and taken outside to a disposal site well away from the processing room. Regular removal is important to prevent the waste from attracting flies to the processing area and to avoid the risk of contaminating good quality fruit.

Careful inspection at this stage can save a lot of time and money later in the process. Good training for inspection staff is important and possibly a bonus scheme should be considered, as proper sorting is one of the most cost-effective ways of improving the value of a raw material. It should be remembered that it is not possible to improve the quality of a raw material by processing it. Poor quality raw materials produce poor quality finished products.

Processing

Resources allocated to testing the finished product should be relatively small compared to those used to monitor the process, because mistakes in the finished product are often too late to correct. It is better to have control of the process to prevent the mistakes from occurring in the first place. This is the basis of the HACCP approach. Management systems should encourage operators to quickly report faults in the product or process. An incentive or bonus scheme may help and any form of penalty should be avoided.

Preparation

The fruit is washed in clean potable water, chlorinated if necessary, as quickly as possible after

inspection (details of chlorinating systems are given in Chapter 1). It is important to inspect the fruit and remove any that are spoiled or damaged before washing as these would otherwise quickly contaminate the wash-water. That in turn would increase the risk of contaminating the other fruit and increase the risk of later problems.

Operators should be trained to inspect fruits for faults, for example, they should check the following:

- **Sorting and peeling is properly done and no peel or rotten fruit passes into the process.**
- **All leaves, insects and other wastes are removed during washing and sorting.**
- **There are few delays during processing.**

Part-processing (intermediate storage)

Two of the main problems facing the processor are the need to process the fruit quickly to prevent further ripening and spoilage, and the need to handle the large amounts of fruit that arrive in the short harvest season.

To avoid investment in large capacity processing equipment which is only used for a few weeks of the season, it is possible to part-process fruits. This prevents further ripening or spoilage and maintains the fruit near its original condition until it is required for final processing. Although it is possible to preserve many fruits by freezing, this is an expensive option and generally not affordable by small scale producers. A more viable alternative is to preserve the fruit with salt, sugar or a chemical preservative. The method selected depends on the finished product to be made (Table 8: Methods for intermediate storage of fruits).

Details of methods to measure the concentration of salt and sugar are given in Chapter 3.

Raw material preparation

Four basic steps are involved in preparing fruits for processing: peeling, slicing, pulping and filtering or straining.

Peeling is usually done by hand with sharp, stainless steel knives although small manual peeling machines are available for some types of fruit (Figure 26: Small fruit peeling machine). The quality check at this stage in the process is to ensure that all peel is removed with a minimum loss of fruit flesh.

Slicing is also often done using knives and this is acceptable if the uniformity of slices is not too important (for example when making chutneys, pickles or bottled fruit). However, a uniform size is essential for products such as banana chips, dried and crystallised fruits and shreds for marmalade. For these products it is recommended that a small slicing or dicing machine is used to obtain uniform sized pieces. A quality check at this stage is to inspect sliced fruit to ensure that pieces are uniform in size and any over-sized pieces are removed or re-sliced.

When making fruit leathers, sauces, jams, marmalades and the many types of fruit drinks (juices, squashes, cordials and nectars), it is necessary to pulp the fruit. In all but the smallest scale of operation, this is best done using a pulper/finisher machine (Figure 27: A pulper-finisher for making fruit pulps).

These are available in a range of different sizes or they may be fabricated by local metal workshops.

Fruit pulps are filtered when a clear product such as squash, jelly or juice is required. This is usually done using a nylon mesh or cloth bag. A quality check at this stage is to ensure that bags are thoroughly cleaned and boiled for at least 10 minutes before each use.

Processing

Batch preparation

Mixing of ingredients to prepare a batch for processing is one of the most important stages in a process. When done properly it results in a uniform product from every batch and can save money by not using excessive amounts of expensive ingredients every time. However, any mistakes that are made at this stage cannot be easily corrected later and may result in non-uniform finished products or having to throw the whole batch away. A record book should be kept in which the batch number is noted and the correct amount of ingredients are ticked off as they are added to each batch (Figure 28: Ingredient record book).

Good quality scales are required for batch preparation and two sets may be necessary; one for heavier weights (for example 50 kg in divisions of 250 g) and one for smaller weights (for example 1 kg in divisions of 2 g). Although scales are generally expensive, especially for accurate types, they can save money in the long term by ensuring that excess ingredients are not added.

If the size of the business does not justify expenditure on scales, it is possible to use calibrated cups, spoons or jugs to measure out ingredients, provided that the same amount is added in every batch. Concentrations of sugar used in syrups or salt used in brines should be checked for each batch (Chapter 3: sugar measurement, salt measurement). In some preparations the amount of acid added to a syrup or

brine is important and should be checked by titration, not by pH (see Chapter 3: acidity measurement).

Process control

Most fruit products are heated to pasteurise them (to destroy enzymes and microorganisms and therefore achieve preservation). However some pickles and chutneys are not heated and preservation is achieved by a careful combination of acids, salt and sugar. In the following section, the three basic methods of processing (drying, heating and pickling) are described in outline, together with the relevant control procedures. More details of the processes for individual products are described in publications listed in Appendix 1.

In all types of process, records should be kept of the amount and type of ingredients used, the process conditions (ea. drying temperatures, heating times etc), the raw material batch numbers and the product code numbers that are printed on the labels. This allows the processor to trace any subsequent faults in a batch of product back to the process or to the raw materials.

Drying

Dried fruits are often pre-treated with sulphur dioxide to maintain their colour, reduce browning and reduce the number of contaminating micro-organisms. This may be done by either dipping the fruit into a solution of sodium metabisulphite or placing the fruit in a cabinet containing burning sulphur. The level of sulphur dioxide is controlled by law in most countries and careful measurement is needed to correctly weigh out sodium metabisulphite when making up a solution or when weighing out sulphur for burning in the cabinet. For this reason the producer should take great care to weigh out sodium metabisulphite correctly when making up the solution. Similarly the weight of sulphur for burning in the

cabinet and the time of sulphuring should be carefully controlled. Details of the permitted levels of sulphur dioxide can be obtained from a local office of the Bureau of Standards, or Ministry of Health, Agriculture, or Trade and Industry, depending on the country.

Crystallized fruits and fruit leathers are pre-treated with sugar syrup and then dried. The amount of sugar added to the soaking solution and the temperature to which the fruit is heated are controlled by careful weighing and the use of a thermometer respectively. Again sulphur dioxide, usually in the form of sodium metabisulphite, is added to help maintain a fresh colour and inhibit mould growth during drying.

Due to their high sugar content,- fruits tend to dry slowly. For this reason the use of artificial dryers is preferred in order to reduce drying times. However, under suitable climatic conditions, solar dryers can perform well. Drying conditions also need to be carefully controlled to ensure that the fruit is fully dried to a sufficiently low moisture content without mould growth. Further details on drying are given in the chapter on Herbs and Spices (Chapter 2.4) and further reading is suggested in Appendix 1.

The shelf life of dried and crystallised fruit depends mostly on the 'equilibrium relative humidity' (ERM) of the product under the expected storage conditions. This is a measure of the amount of water that is available within the product that can support the growth of contaminating micro-organisms. This is usually found by measuring the moisture content of the product (Chapter 3: moisture content measurement, fruits), but the relationship between moisture content and ERH varies with different foods and so it is necessary to find out by experiment what is the highest moisture content that will allow the food to be stored without spoiling. In practical terms this can be done by removing samples at different times during a drying test, packaging them and checking to see which ones develop mould after a few weeks of storage. Moisture checks are then made on samples that do not show mould

growth and this is used to find the highest moisture content that can keep the food stable.

Heat processing

Products such as sauces, preserves (jams, jellies, marmalades), fruit drinks, fruit toffees and bottled fruits are each heated during processing. This is usually done by heating the food in boiling pans and then hot-filling into pre-sterilised jars or bottles. Alternatively the product can be filled first and then heated in the container. In both cases the time and temperature of heating is an important quality control measure. Too much heat reduces the quality of the food by excessive softening, loss of the colour or flavours. Too little heat results in survival of enzymes and contaminating micro-organisms, which could lead to mould growth and loss of texture or colour during storage, and in the case of drinks, separation of pulp forming a sediment in the bottom of the bottle.

It is essential that the correct temperature and time of heating are carefully determined for each product and that operators are trained to ensure that these conditions are maintained for every batch. Normally a clock and a thermometer are sufficient to control the process, but for preserves, toffees and sauces, this is not sufficiently accurate and a refractometer is used to check the final solids concentration (see Chapter 3: sugar measurement).

Pickling

Chutneys and pickles may be pasteurised but usually they rely for their preservation on the correct balance of acids, salt and sugar in the finished product. The preservative action involves inhibiting enzymes and micro-organisms but they are not destroyed. Therefore strict control over hygiene is essential in the preparation and processing of fruits for these products (see Chapter 1.3). In particular,

insects may carry moulds and yeasts into the product during the pickling process and these may later grow and cause fermentation or mould growth during storage. The product should therefore be protected from insects and covered at all times to stop dust and other contamination. A well-made pickle will remain useable for several months after opening without the use of preservatives and although many manufacturers use sodium benzoate, this is not strictly necessary.

The batch formulation needed to achieve the correct balance of salt, sugar and acids should be carefully calculated using the formula below to ensure a 'preservation index' above 3.6%.

$$\text{Preservation Index} = \frac{\text{total acetic acid acidity}}{(100 - \text{total solids})} \times 100$$

Methods for measurement of acidity and total solids are given in Chapter 3 (acidity measurement, salt measurement, soluble solids content measurement by refractometer, moisture content).

Once a suitable recipe has been developed, it should be carefully controlled by accurate weighing of ingredients during the preparation of every batch. The concentration of salt, sugar, vinegar (acetic acid), other acids (ea. citric acid) or chemical preservatives such as sodium benzoate, should each be measured to ensure that the product will remain stable during storage (see Chapter 3: acidity measurement, salt and sugar measurement).

Packaging, storage and distribution

Packaging

Glass jars and bottles are commonly used to pack fruit products but other cheaper containers such as plastic pots and plastic bags are becoming increasingly common. There are a number of quality checks that must be done when using glass containers (see Chapter 3: glass container measurement) because of the risk of glass splinters entering the product and causing serious harm to consumers. Checks on plastic containers are less rigorous and these are also outlined in Chapter 3 (plastic container measurement).

All products should be carefully filled to ensure that the amount in the container is the same as the net weight described on the label. In most countries it is an offence in law to sell an under-weight product and over-filling means that the company is giving away product at a loss. Further details of labelling requirements are given in publications described in Appendix 1.

For liquid products such as drinks, sauces, hot filled chutneys and preserves, a piston filler (Figure 29: A piston filler for filling liquid foods) gives more accurate fill weights than manual filling. Solid products such as dried fruits, crystallised fruits, bottled fruit pieces and cold filled chutneys and pickles are usually filled by hand.

A check-weighing scale (Figure 30: A check-weighing scale in use) can be used to ensure that the correct weight is filled. This equipment is also used to check the weight of samples taken regularly from batches of liquid products. Control methods for fill-weights are described in more detail in Chapter 3 (fill-weight measurement).

Seals on lids of bottles and jars should have close and continuous contact with the glass rim. Plastic and glass seals should not be contaminated with product or else the seal will leak. Packs should be checked to ensure that the correct label is used for each product, that the date stamped onto the pack is correct

and that code numbers are correct and are changed regularly (each batch of product or each day's production).

Storage and distribution

Once a fruit product has been processed and sealed into a container the risks of contamination by insects, dust and micro-organisms is reduced but further damage to the food is not eliminated. Incorrect storage conditions, such as exposure to sunlight, heat and water or incorrect stacking which causes crushing, can all result in spoilage of the processed fruit. This is particularly important because of the money that has already been spent on processing and packaging the food. Losses at this stage are financially very damaging.

Packaged foods should therefore be stored in cardboard (paperboard) boxes on pallets or shelves that keep the boxes off the floor of the store-room. Boxes can be stacked on top of each other provided that the combined weight of the stack does not crush the bottom box. The store-room should be cool and dark with a good ventilation to maintain a flow of air. Many manufacturers give careful attention to the construction of a processing area but forget about store-rooms. As a result they suffer financial losses because ingredients, packaging materials and finished products become damaged during storage. The details of building design and layout described in Chapter 1.2 should be applied equally to processing and storage rooms. In particular windows should be screened against insects and the structure of the roof and walls should prevent rats and birds from gaining entry.

An important aspect of storage and distribution is to develop a management system to monitor which products are in the store, to control stock rotation and record their destination for delivery. This is particularly important when a processor produces a range of products, as it is very easy for slower-

selling products to be hidden at the back of a store and go beyond their 'sell-by' date. Simple records (Figure 31: Simple records for storekeepers) should be kept by storekeepers to show which products and materials are transferred into and out of the store-rooms.

Go To Next Page

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

2.4 Herb and spice products

Contents - Previous - Next

The process flow chart for selected herb and spice products is shown in Fig. 32 (see Figure 32: Process flow diagram for herb and spice processing) and a summary of the main quality assurance procedures for herb and spice processing is shown in Table 9 below. The quality assurance procedures in the table are discussed in more detail in the following chapter.

Table 9: Main quality assurance factors for herb and spice processing

Hazard	Risk
Non permitted pesticides/ herbicides	Very high, sale may be impossible. Liaison with

	growers.
High levels of permitted pesticides/herbicides.	Very high. Liaison with growers.
Infestation	High, fumigation may be required.
Foreign matter	Medium. Can be removed. Sorting.
Poor microbiological quality.	Medium. Improve harvesting, handling and washing.
Mould growth after packaging.	High. Dry to correct moisture content. Improve packaging materials.

Introduction

Most dried foods are comparatively low risk products in terms of causing food poisoning as they rely upon drying to a sufficiently low moisture content to prevent the multiplication of micro-organisms. However, herbs and in particular spices, are an exception and commonly contain very high levels of micro-organisms including those that cause food poisoning. In addition, they are commonly subject to contamination with foreign matter.

There are two main reasons for these high contamination levels. First considerable contamination occurs during harvesting, washing and sun drying which takes place 'on farm', often under primitive conditions. Secondly, subsequent processing of herbs and spices is restricted to low temperature drying, grading, cleaning and grinding. They are not heat treated because this would result in loss of flavour and micro-organisms may thus survive processing. Fortunately for the producer, public health risks to the consumer are greatly reduced as herbs and spices are used as minor flavouring ingredients and well

cooked in the home.

The quality assurance and control procedures that need to be considered when processing herbs and spices fall into three main areas:

- **Cultivation practices, harvesting and primary processing by growers.**
- **Processing methods in the production unit.**
- **Packaging and storage after processing.**

The manufacturer needs to consider each of these aspects in detail and develop a HACCP plan to identify problem areas, potential hazards and to put checks into place at critical points to meet the central objective: that is to supply high quality products to the consumer.

From cultivation to raw material purchase

In most developing countries herbs and spices tend to be grown by smallholders. Their high value means that a good financial return may be obtained for people possessing a small plot of land. This has several immediate implications for the purchaser including:

- **In many cases smallholders are the poorest farmers so their level of education may be low. As a result they may resist changes if not properly informed.**
- **A reluctance by the grower to reject any substandard material because of its high value. This may result in a grower blending a little poor quality material with good quality crop.**
- **It is difficult to monitor and control growers who might be tempted to use non-permitted pesticides and herbicides. In addition small scale growers often use fresh animal manure as a fertilizer which**

may cause heavy contamination with micro-organisms which cause food poisoning.

- As material may come from many small scale producers a high level of raw material inspection is needed, which has a higher cost.
- Farm dried spices and herbs are commonly subject to infestation by insects and rodents due to the poor conditions under which they are stored.
- Most smallholders sell small quantities, often only a few kilograms, to intermediaries or traders. These traders may resort to malpractices such as adulteration with low value materials or adding water to increase weights.
- In the case of spice crops preliminary processing such as washing and drying is carried out by the grower or agent. In many cases the quality of the water used is poor and washing may do more harm than good.
- Traditional drying methods in which the product is spread out in the sun, hopefully on a mat, are a source of contamination by foreign matter. The authors have on many occasions seen dogs and cats asleep on a nice warm bed of spice!
- In many countries harvest times tend to coincide with rainy weather. Drying may then take several days with occasional wetting by rain if the producer is not quick to cover the crop. This slow drying encourages the growth of micro-organisms.

Quality assurance in raw material supply

Processors thus face a complex range of problems even before the product enters the processing unit and at first sight these appear to be beyond their control. However, as has been stated in other chapters of this book, 'a good product cannot be made from second rate raw materials'. For this reason the greatest gains in finished product quality may be made by carrying out a HACCP analysis that

focuses on these pre-purchase areas.

The first step is to understand the supply chain from grower to purchaser and then identify all potential hazards and their severity.

The next step is to consider what can be done to eliminate or minimise these risks. In this context, the most important aspect is the relationship between the growers and the buyer. Each must have confidence in the other. The processor should consider ways in which the grower may be assisted and this will also give greater confidence over the raw material quality. Ways of helping are many and varied but the following examples may guide the reader to develop the correct tactics and systems.

Many smallholders are forced to sell through agents as they are also a source of credit during periods of hardship or when material inputs are required. The entrepreneur may assist in a similar way by offering contracts with phased payments against an agreed quality standard. This may be particularly useful for buying inputs such as herbicides and pesticides. The entrepreneur may purchase these in larger quantities at lower prices and distribute them to growers in the correct amount, depending on the area of the crop to be treated. In this way the buyer has considerable control over both the type and level of chemicals used. In other cases the distribution of selected seed may provide the farmer with higher yields and give the buyer more uniform raw materials.

Investigation and training are also good ways to improve quality. A buyer is often well placed to organise and fund such activities, as the following account from Guatemala in Central America shows: here smallholder members of a co-operative were attempting to supply herbs, which after drying were to be sold to a major multi-national food company which applies very high quality standards. Despite rigorous washing and sanitising, it proved impossible to meet the company's microbiological standards.

A local institution carried out some tests which showed heavy contamination not only on the outer surface of the plants but also internally. It was clear that simple washing would never solve the problem, but the final solution proved to be very simple. First the use of raw manure as a fertilizer was stopped as this was the major source of contamination. Secondly harvesting methods were changed and the cut herbs were placed in clean baskets off the soil instead of being laid on the ground. It had been shown that when a plant is cut, its stem attempts to seal itself by sucking up moisture, which in this case contained microorganisms from the soil. The farmers were trained in the proper management of manure and hygienic harvesting. The problem disappeared and a contract was won.

Farmers may also be trained to construct and use solar dryers that can provide substantially more hygienic drying conditions. A typical low cost dryer constructed from readily available materials is shown in Fig. 33 (see Figure 33: Brace type solar dryer costing about US$ 20 and capable of drying 10 kg of produce per batch). Such training should however stress that the role of the dryer is not to dry more quickly, but to give a better quality product.

Dried spices that are stored on the farm often become rapidly infested with beetles and moths. Growers usually put dried products in dirty gunny sacks which are laid on the floor in a corner of the house. Training in correct storage methods may dramatically reduce infestation levels and buyers may also directly assist the growers by providing heavy-gauge plastic bags or large tins with lids for on-farm storage.

The technique of "sunning" is used to prevent infestation of grains by heating them in the sun and this is also applicable to spices (see publications in Appendix 1).

In many cases growers wash herbs and spices using heavily contaminated water. Training farmers to

add a little household bleach to the water will reduce levels of contamination (see Chapter 1.3 and Chapter 3: chlorine measurement).

It may also be better for buyers to avoid purchasing from traders. Larger businesses may find it worthwhile to have a trained employee who is responsible for visiting farmers and purchasing their crops. It is easy to check the quality of a small amount of reasonably uniform material from one grower. However, it is exceedingly difficult to assess the quality of several tons of mixed crops that may have originated from perhaps 100 growers.

To summarise, it is possible for an entrepreneur to improve the quality of incoming herbs and spices by finding ways to have more control over their production, including for example:

- **Forming good relationships with a group of trusted suppliers.**
- **Having one person responsible for purchasing.**
- **Assisting and controlling farm inputs.**
- **Providing phased payment contracts with mutually agreed terms.**
- **Arranging training and funding occasional investigations.**
- **Carrying out regular visits to growers to make sure bad practices are not occurring.**
- **Arranging collection of harvested material. The shorter the time between harvest and processing the better the product quality.**
- **Where possible, discouraging on-farm washing and drying. If the produce can be moved quickly from the farm to the processing unit it is better to carry out these steps in a controlled way 'in-house'.**
- **When buying from larger producers or agents, samples should be taken and tested prior to**

purchase. Also inspection of suppliers' stores may indicate if they are clean and have any signs of insect or rodent infestation.

Quality assurance and control in the processing plant

It has been repeatedly stressed in this book that high quality finished products can never be made from poor quality raw materials. Although all stages in a process are important, errors in early stages build up, becoming larger problems later, which cannot usually be corrected. Careful attention to the initial stages of a process is therefore very beneficial in maintaining quality.

The first step in the process is to check each batch of incoming raw material and record the results against the name of the supplier in an Incoming Materials Test Book (Fig. 25). Most dry spices and herbs are delivered in gunny sacks and a 'thief sampler' (Figure 34: A thief sampler being used to take representative samples) is useful to remove samples from the centre of the sack for testing.

The most common checks that a small or medium scale producer can carry out on fresh material include the following:

Appearance and presence of contaminants

A sample of the incoming raw material should be spread on a sheet of clean paper and carefully examined for signs of infestation, moulds, foreign matter, rodent hairs, broken seeds etc. In some cases, placing a small sample in water may reveal spices which have been internally attacked by insects as they will tend to float. In other materials the size of pieces may be important and a simple test procedure can be developed to check the range of sizes, by either sieving or weighing a known number

of seeds (Chapter 3: sieving tests). A 'filth test' (Chapter 3) can be used to identify insect parts.

Odour and flavour

Small and medium scale producers are not able to chemically analyse the flavour-bearing essential oils in the product. With experience however, abnormalities may be detected by tasting.

In the case of a unit processing dried herbs and spices, a similar examination system to that used for fresh crops is required, together with a determination of moisture content.

Moisture content

The moisture content of dried herbs and spices is very important and if it is too high moulds and yeasts will be able to grow. The grower is always anxious to sell the maximum amount of water! The moisture content may be checked using scales and an oven (see Chapter 3: moisture content measurement, spices).

Control of processing

The processing of herbs and spices usually involves most of the following stages:

- **Washing**
- **Grading and cleaning**
- **Drying**
- **Grinding**

- **Packaging**

The factory may thus require two areas: a wet area and a dry area (Figure 35: Plant layout showing wet and dry areas). The general recommendations on hygienic management of food processing buildings and equipment described in Chapter 1.2 apply to this process.

Washing

Washing most commonly takes place when fresh herbs are delivered to the processing unit. Spices are rarely washed, but notable exceptions are nutmegs which are dipped in water to remove unsound nuts or "floaters", and cardamom which may receive a sodium bicarbonate dip to preserve its green colour.

In the case of herbs it is most important to wash them as soon as they arrive in order to remove 'field heat' and thus slow down the growth of micro-organisms. Large amounts of clean chlorinated water are required, using chlorine levels that are higher than those found in tap water. Chlorine levels should be monitored to avoid flavour taints in the finished product and simple test kits are available (Chapter 3: chlorine measurement).

If available, special disinfecting/cleaning agents are superior to chlorinated water. These usually contain chemicals known as quaternary ammonium compounds that have a stronger, longer lasting action than chlorine. They are usually supplied pre-mixed with wetting detergents that produce better washing.

Washing may be achieved at a small scale in large shallow tanks that allow operators to move the produce freely through the water. If concrete tanks are used they should ideally be tiled. Soil and other

foreign matter is washed off the raw materials and frequent changes of water are therefore needed. A better method is to continuously circulate water through a filter. Ideally several tanks should be used, the first for removal of heavy soiling and subsequent cleaner tanks for final washing.

At a larger scale continuous washers are more appropriate. Here a moving conveyor picks up the produce and carries it under powerful sprays of water. Recirculation through a filter is normal to reduce water consumption.

Although spices are rarely washed in most processing units, rapid washing and redrying offers the greatest potential to improve quality. Most contamination by micro-organisms and soils on spices such as black pepper, cardamoms and pimento is surface contamination. Washing or spraying for a minute or so with chlorinated water removes most soils and reduces microbial levels. Quick washing only wets the surface and a short re-drying period is all that is required to reduce the moisture to the required level.

Other cleaning methods

Winnowing is carried out to remove stones, chaff, dust, broken seeds, etc. from dry spices. This may be carried out very simply using a winnowing basket and allowing the wind to blow away light material such as dust or chaff. Stones are removed by hand. Such simple methods are only suitable for very small quantities of raw material. Cleaning of leafy herbs has to be done manually and any unsound material or foreign matter removed.

Small enterprises generally use electric powered winnowers which have a variable speed fan and adjustable baffles that separate stones from sound material and light material (chaff, dust). It is recommended that the weight and type of contaminants from each supplier are recorded in the Raw

Material Inspection Book so that low quality suppliers may be identified.

Drying

Various types of dryers are used for processing herbs and spices, ranging from simple sundrying to gas or kerosene-fired dryers. A common example is shown in Fig. 36 (see Figure 36: Batch tray dryer).

A detailed explanation of such dryers is not possible in this book but useful publications are listed in Appendix 1.

The type of dryer that is used and the way in which it is operated may have a significant influence on the quality of the finished product in the following ways:

- Contamination by dust and dirt.
  There is obviously a high risk of contamination occurring if the raw materials are laid out in the sun. Solar and powered dryers protect against contamination and are thus strongly recommended. It should be noted that fan driven dryers may suck in fine dust particles in dusty areas. As mentioned in Chapter 1.2, short cut grass around the processing area reduces the risk of airborne dust causing contamination of the product. In very dusty areas, powered dryers may need a muslin filter over the air inlet.
- Drying time and temperature.
  During the early stages of drying, conditions in the dryer (high humidity and moderate temperature) are ideal for the growth of micro-organisms. The quicker the drying time the better the final microbial quality of the product. Drying rates may be increased in two ways: by increasing the air flow and by increasing the air temperature. However temperatures should not

be too high as they cause damage to the product. This is particularly true of herbs and spices as there is the risk of losing delicate flavours or colours. The processor therefore needs to experiment and find the best temperature for each product.

Herbs and spices must be dried to a moisture content that is low enough to prevent the growth of micro-organisms such as moulds and bacteria.

Storage

After drying, the material should be packed quickly into clean heavy-gauge plastic sacks to avoid any moisture pick-up. Workers should not directly handle the food, but use scoops or clean gloves. Sacks should be labelled and dated and samples should be taken for moisture testing. It is a good idea to retain samples in airtight bottles for future reference.

Dried products must also be stored under proper conditions, off the floor on wooden pallets and away from walls so that the store-room may be kept clean. Herbs may lose their bright colour if exposed to sunlight and over-wrapping with black plastic sheets is recommended. The store should be regularly inspected and cleaned and stock should be used in rotation.

Grinding

In some cases spices may be sold ground or blended to form a mix such as curry powder. Grinding is normally done using either a hammer mill or a disc mill. Ground spice should be passed through a fine sieve to give a product with a uniform particle size. Finely ground spices absorb water much more quickly than whole spices and it is important that the ground material is quickly packed into airtight

containers.

Grinding may give rise to a considerable amount of fine dust which attracts insects. Ideally the mill should be housed in a separate room that can be thoroughly cleaned at the end of the day. A small vacuum cleaner is recommended for cleaning up fine dust as brushing tends to push dust into the air for it to settle elsewhere. Fine spice dust may be an irritant to workers and protective masks and goggles should be provided.

Packaging and storage of finished products

The type of packaging needed for herbs and spices depends on the product, the intended market and the types of climate that the food will be exposed to. A herb or spice that is marketed in a cool dry area may only need simple packaging such as paper. The same product sold in a hot, humid area needs considerable protection against moisture pick-up. Producers may therefore need to decide on different packs for different markets. Selection of packaging requires much thought and attention as it represents the final defence for the product in the chain to the customer. Some useful publications on packaging are listed in Appendix 1.

Most herbs and spices are packed in plastic film as either large bulk bags or small retail packs. The processor may carry out a number of simple checks on films (see Chapter 3: packaging film measurement).

Contents - Previous - Next

Chapter 3 Simple methods for quality control

Contents - Previous - Next

The methods described below have been included because:

- **They are each relatively simple to use.**
- **They have sufficient accuracy for quality control.**
- **They do not require sophisticated or expensive equipment.**
- **They do not require a high level of skill to operate.**
- **They are sufficiently inexpensive that they may be used regularly by small food businesses.**

It should be noted that many of the methods described in this chapter are comparative and not absolute methods. In other words the results may be used to give a comparison with other results obtained by the same method but they cannot be compared to results found using a different method. For most purposes this is acceptable for routine quality control but it should be emphasised that careful attention is needed to ensure that exactly the same procedure is used on each occasion.

Acidity measurement

To measure the amount of acid (such as citric acid, acetic acid, lactic acid, etc.), it is necessary to titrate a sample of the food with sodium hydroxide solution. It is not sufficient to measure the pH of a food (see pH measurement below) as this does not tell you the amount of acid present.

The method involves the following steps:

1 take a 10 ml sample of liquid food or 10 g of solid food

2 if solid, the food should be liquidised to a fine pulp

3 mix the sample with 90 ml of distilled water, making sure that it is completely mixed

4 add about 0.3 ml of an indicator solution (eg 1% phenolphthalein in 95% solution of ethanol)

5 fill a burette (Fig. 37) with 0.1 M sodium hydroxide solution (obtainable from larger pharmacies) and titrate the sample until there is a pink colour that does not change.

6 calculate the amount of acid as " % acid per ml of liquid food" or "per g of solid food" using the formula: % acid = number of ml of sodium hydroxide x one of the conversion factors below:

acetic acid (vinegar) 0.060

citric acid 0.070

tartaric acid 0.075

lactic acid 0.090

It is necessary to know what is the major acid present in a type of food before selecting the conversion factor.

Figure 37: A burette used for titration

Chlorine measurement

The determination of levels of chlorine in water is usually carried out using a calorimetric test in which a chemical dye, which reacts with chlorine, produces a colour that is proportional to the amount of chlorine present.

The test requires the use of a 'Lovibond Comparator' (Figure 38: A comparator, used to test chlorine levels in water). This is supplied with a number of discs of coloured glass that are calibrated for different chlorine levels (eg 1 to 10 ppm, 10 to 50 ppm etc).

In use, a few drops of the dye are placed in test tube. The water under test is added and a colour develops. The tube is then placed in the comparator and the colour is matched with one of the calibrated discs.

These chlorine test kits are available from a number of suppliers and it is suggested that those considering testing chlorine levels in water should consult the local Water Department which will be able to advise on the nearest source of supply and possibly provide training in the method.

Fill-weight measurement

In most countries there are legal requirements which state that a container has the weight of its contents written on the label and that the net weight of food inside is not less that this weight. This should be routinely checked by taking regular samples of filled containers and placing them on a scale (Fig. 24). On the other side of the scale there is the heaviest empty container from a batch (see 'weight of glass containers' below) plus a metal weight that is equal to the net weight shown on the label. Filled containers that are underweight should be removed and re-filled. The results of these checks should be recorded on a chart and related back to the worker who is filling the containers or operating a filling machine to ensure that accuracy of filling increases with experience gained.

It should be noted that this is the "minimum weight" method of checking fill-weights. It is intended to ensure that all packs contain more than the net weight shown on the label and it is a simple system for small scale producers to operate. There is however another system, known as the "average weight" system, which relies on the statistical probability that a known proportion of packs will be above the net weight. This system was developed in Europe for automatic filling operations and is un-necessarily complex for small scale producers. However if exports to Europe, USA or some other countries are contemplated, then it is recommended that details of this system should be obtained from a local Export Development Board or its equivalent.

Flour infestation

1 100 grams of flour is weighed onto a flat surface.

2 Flour is flattened using a ruler.

3 Flour is examined after two minutes for evidence of pimpling, i.e. surface disturbance.

Pimpling indicates the presence of flour mites breaking the surface for air.

Glass container measurement

Glass containers have more variable dimensions than either plastic or metal containers because of the nature of their manufacture. It is therefore important to check particular dimensions to ensure that a) a container has the expected capacity; b) that the neck is properly formed and will allow the lid to fit properly; c) that the container is vertical to prevent it breaking in a filling machine, and d) that the weight of a sample of empty containers is checked to find the heaviest in a batch for use in check-weighing.

Glass pieces are also a particular danger to customers if they become mixed into the product. It is therefore essential that the checks described below are routinely performed on all glass containers.

Finally glass containers are often re-used and may have become contaminated by kerosene, pesticides or other materials. They should be thoroughly washed and inspected by looking and smelling to ensure that no residues remain before the food is filled.

Weight of containers

Take a random sample of empty containers from an incoming batch (for example 1 in 50) and weigh them, together with their lids. The required check-weight is calculated as the weight of the heaviest container plus the net weight of product.

Capacity of containers

Weigh a dried container and then fill it to the top with distilled water at 20C. Reweigh the filled container and the difference in weight (in grams) is equivalent to the capacity in ml. This capacity should be great enough to allow sufficient food to be filled to meet the net weight declared on the label.

Headspace

A space is required between the surface of a hot-filled product in a jar and the underneath surface of the lid. This allows a partial vacuum to form when the product cools and thus helps to prevent spoilage. The volume of the headspace does not normally exceed 10% of the capacity of the container. Measuring the depth of the headspace is a quick method of assessing the volume, but the depth varies according to the capacity of the container (larger containers require a deeper headspace).

A headspace gauge (Figure 39 : A headspace gauge used to check the depth of a headspace) is a cheap and simple way of routinely checking that product has been filled to the correct level. It consists of a series of prongs of different lengths fixed onto a bar and it is placed on the rim of the jar before fitting the lid. The level of product may then be seen where it touches one of the prongs. Alternatively a device (Figure 40: A simple way of ensuring a consistent headspace) can be fitted into the production line to maintain a uniform headspace.

Vacuum

The partial vacuum in hot-filled glass jars may be measured using a Bourdon tube vacuum gauge (Figure 41: A vacuum gauge for measuring headspace vacuum). The gauge is fitted with a sharp needle, surrounded by a rubber seal. The needle is pushed through the lid of the container and the moistened rubber seal prevents air from entering. The partial vacuum may then be read directly from the gauge as 'mm of mercury' or 'minus kPa'. As the product is not saleable after this test, it is usually only applied to a small sample or when a problem arises.

Dimensions of containers

The important routine checks are to measure the height of containers, their neck diameter and outside diameter, and their ovality (to ensure that they are round and not oval). Simple equipment may be manufactured to perform these checks (Figure 42: Simple equipment for checking glass containers: a)

height measurement, and b) go/no-go rings). A vertical ruler on a stand is used to measure height. Different "go/no-go" rings can be made for each size of container that is used. Rings are slipped over the neck of a container to quickly show whether the diameter is too large or too small for the intended lid and also to show if the neck is not circular. Different sized rings can similarly be used to check the outside diameter of the container and its ovality.

Faults in glass

It is essential that all glass containers are visually checked to make sure that no glass splinters or cracks are present. Common faults in glass are bubbles, cracks and strings (Figure 43: Serious faults in a glass jar). A light-box, in which a light bulb is placed behind a translucent plastic screen, is useful to view glass containers clearly. Operators who check glass containers should be fully trained in which faults to look for and they should be moved from inspection after 3060 minutes to prevent tiredness and lack of concentration.

Gluten measurement

1	Weigh 10 + 0.01 g of flour and place in a basin.
2	Add 6ml of water to the basin, (5 ml will be sufficient for weak flour).
3	Using a spatula, mix the flour and water into a dough. Form the dough into a round ball by rolling between the palms of the hands.

4	Replace the dough in the basin and cover it with water. Leave for a time, at least 10 inutes, preferably 45-60 minutes.
5	Holding the dough ball in one hand under cold running water, wash out the starch. Squeeze the dough frequently between the fingers and the palm to help the process.
6	When all the starch has been removed the wash water will run clear and the remaining gluten will be free from lumps.
7	Remove the excess water with blotting paper.
8	Weigh the wet gluten and record this as a percentage of the flour weight.
9	The gluten may be dried in an oven at 103C to determine dry gluten.

The gluten obtained at step 7 may be physically examined for strength and elastic properties by pulling the gluten apart.

Label measurement and quality checks

It is often forgotten that labels are an integral and important part of a food product. They need to be tested and checked in the same way as any ingredient. On delivery, samples should be taken from each pack of labels for examination as faults may develop in a print run. All packets of labels should then be repacked and sealed.

Label faults may be divided into major and minor faults. Major faults include:

- The use of incorrect colours.
- Major variations in dimensions.
- Information missing, wrongly printed or mix-spelt.
- Major print errors, slippage.
- No glue, if applicable.

Labels showing major faults should not be used and should be returned to the printer.

Minor faults include:

- Detectable but acceptable colour variations.
- Size error but label usable.
- Minor colour registration errors.

Labels with minor faults may be used but the problems should be discussed with the printer and possibly a reduction in price negotiated.

Loaf volume measurement

It is usual to use a simple device in which the displacement of rapeseed or mustard seed is measured. This is accurate because the individual seeds are hard and quite round, flow easily, do not disintegrate and a given weight always occupies the same volume. There are two rectangular compartments, connected by a graduated cylinder made of glass or transparent plastic. The equipment may easily be

inverted, allowing either compartment to be uppermost. An adequate amount of seed is placed inside and flows from one compartment to the other as the apparatus is inverted. With the seed in one compartment in the lower position, the loaf under test is placed in the top compartment which is then closed and the apparatus is inverted so that the seed fills the space around the loaf and levels off in the tube. The bigger the loaf, the higher up the tube will be the surface of the seed layer. The actual volume is read off from the graduations on the tube, which is previously calibrated. Loaf volume is usually expressed in cc's and the volume of 1 lb loaves may vary between 1,400 cc's and 1,600 cc's, depending on the flour used.

An indication of volume may quickly be obtained by measuring the maximum height of the loaf. This is useful but because of the irregular shape involved, it is not very accurate.

Moisture content measurement: grains

With experience, an operator may assess the correct moisture content of grains by placing them on a hard surface and tapping them with a metal or stone weight. The hardness (or softness) of the grain indicates the approximate moisture content.

A more accurate but more time consuming method is to dry a weighed sample of grain in an oven at 100C for 5 hours (or 104C for 2 hours) and re-weigh. Certain items of equipment are needed to determine the moisture content: a balance accurate to three decimal places (ie 0.001 g), a thermostatically controlled oven and a laboratory desiccator. A sample of material is dried to constant weight and the loss reported as moisture content.

Approximately 2 g of the material under test is accurately weighed (to 0.001 g) into a small dish. This is then placed in the oven for 1 hour, removed from the oven and put in the desiccator to cool. It is then weighed. The dish is replaced in the oven for 30 minutes and the process repeated to constant weight.

The moisture content is found using the following formula:

$$\%\,\text{moisture} = \frac{(\text{initial weight - final weight})}{\text{initial weight}} \times 100$$

A faster but more expensive method is to use a moisture meter. This measures the conductance of electricity through a sample of grain to indicate the amount of water it contains. The instrument is expensive and therefore likely to be affordable only by larger scale millers.

Moisture content measurement: fruits.

This is measured by oven drying as described above for grain moisture content measurement.

Moisture content measurement: spices.

This is measured by oven drying as described above for grain moisture content measurement. However, it is likely that volatile oils from the spices will also be evaporated and care should therefore

be taken when interpreting the results of such tests. Drying at a lower temperature using a vacuum oven is likely to be too expensive for most producers.

Solids content measurement

The method involved is the same as that described for moisture content above, but the result is expressed as ' % solids'. This is calculated using the following formula:

$$\% \text{ solids} = \frac{\text{final weight of sample}}{\text{initial weight of sample}} \times 100$$

Packaging film measurement

Made-up plastic bags and rolls of film need to be checked and there are a number of simple tests that a small food processor may carry out. It should be remembered that there is no way of checking for faults inside a roll of film as only the outer part may be seen. Rolls thus need to be examined during use. Typical faults in plastic bags and films include:

- Incorrect yield. The barrier properties of a given type of film depend on its thickness. The normal way to measure thickness is by weight per square metre. Using a template 10 squares of film, each 10cm by 10cm are cut out. These are then carefully weighed. The result (in grams/square metre) is then checked against the supplier's specifications.

- Incorrect printing. This is described in more detail under quality control of labels.
- Odour. Some films are manufactured using solvents and rolls should be checked for any such smell by crumpling a sample in the hand and smelling it.
- Blocking. This fault results from layers of film on a roll sticking together. Blocking rarely causes serious problems unless automatic packaging machines are used.
- Seal strength. Samples of film should be heat sealed and the seal strength checked by pulling the seal apart. The same test should be applied to made-up bags.
- Curl. This causes the film to curl up rather than lay flat. It is caused by the film being poorly stored, particularly in conditions that are too damp or too dry.

pH measurement

pH is a scale that is used to describe acidity (pH 1-6), neutrality (pH 7) or alkalinity (pH 814). There are two methods of measuring the pH of a sample of liquid food: the simplest and cheapest is to dip a piece of pH paper into the sample. The paper is impregnated with chemicals that change colour and the colour may be compared to a chart supplied with the paper to give the pH of the sample. This method is often sufficiently accurate for routine Q checks.

If greater accuracy is required a pH meter should be used. These may be mains powered bench models or battery powered portable models (Figure 44: Bench mounted and portable pH meters). In general bench models are more accurate than portable types, although newer equipment has reduced this difference. Bench types are more expensive than portable types and, when properly maintained, may

have a longer working life. If voltage fluctuations are a problem, bench models require a voltage regulator to be fitted.

Modern portable pH meters are fitted with a container filled with buffer solution when they are delivered. This should be replaced as directed in the suppliers instructions. New electrodes for bench models should be soaked for several hours in distilled water or buffer solution. Afterwards they should be stored with their tips in one of these solutions. Older electrodes may be cleaned by placing in 0.1 M sodium hydroxide solution for 1 minute and then in 0.1 M hydrochloric acid for 1 minute, repeated twice. They are then rinsed in water and carefully blotted (not wiped) with a soft cloth or tissue paper.

pH meters should be standardised against buffer solutions which have a known pH. The standardisation and later pH measurements should all be done at the same temperature (between 20-30C) to avoid errors in the results.

In use the instructions supplied with the equipment should be carefully followed. For example the instrument has a temperature compensation control that should be set to the local ambient temperature.

The general procedure for measuring pH is as follows:

1. **Standardise the instrument using a commercially supplied pH 4.0 buffer or freshly made 0.05 M potassium acid phthalate solution (10.12 g of the chemical in 1 litre of distilled water). Dip the electrode into the buffer and adjust the standardisation control so that the scale reads pH 4.0.**
2. **Rinse the electrode in water and carefully blot (not wipe) clean with a soft tissue.**
3. **Check the pH of a commercially supplied pH 7.0 buffer or 0.025 M potassium dihydrogen**

phosphate solution (3.387 g of the chemical dissolved in 1 litre of distilled water).

4. Repeat step 2.
5. Place the electrode in a sample at the same temperature as the buffers (between 20-30C) and allow the instrument to stabilise for 1 minute. Repeat step 2 and take a second reading. The two results should be within 0.1 pH units of each other.
6. Store the cleaned electrode in distilled water or buffer solution and switch the instrument to 'standby' when it is not being used.

Plastic container measurement

There are fewer checks that are needed on plastic containers, compared to glass containers. This is because the method of manufacture results in more uniform dimensions, the weight of the container is small compared to glass and variations are therefore less important. The main faults are likely to be splits, punctures, a badly formed neck and the use of non food-grade plastic. With the exception of the last fault, each can be checked visually by operators involved in filling the containers. There are no simple checks to ensure that a container is made from food grade plastic and if there is any doubt the processor should consult a reputable supplier for advice. They may be checked to ensure that the seal or cap is water-tight by simply inverting a sample of filled containers to detect leaks.

Salt measurement

There are three methods that can be used for measuring the salt concentration in foods: hydrometry, refractometry or salt titration. In the context of this book, the main application is checking the salt concentration of brines and hydrometry is the recommended method. Refractometers are expensive and the titration method is more complex and requires training and laboratory chemicals.

Hydrometers are hollow glass rods with a bulb at one end (Figure 45: Hydrometer for measuring salt concentration in brine). They are sealed at both ends so that they float when immersed in a liquid. The bulb is weighted so that the hydrometer partially sinks to a level that depends on the specific gravity of the brine (the more salt that there is in a solution, the higher the specific gravity). A scale on the stem of the hydrometer is calibrated and may read from 0-100 degrees, where 0 is pure water and 100 is saturated salt solution (26.5%). It is important that the measurements are made at the reference temperature for the hydrometer (usually 20C) because the specific gravity of the brine changes at different temperatures.

The method of measurement involves placing a sample of brine at the correct temperature into a large clear glass or plastic cylinder and gently lowering the hydrometer into the liquid. When it has stopped moving, the scale is read at the surface of the liquid and the reading is converted to % salt using a conversion table supplied with the hydrometer.

It is important that a salt hydrometer is specified as there are other types that are calibrated for alcohol or for sugar solutions.

Sieving tests (flours and spices)

A 500 g sample of flour or ground spice is sieved through a stack of metal sieves with the largest mesh at the top of the stack and the smallest at the base. Typically the range of sieve aperture sizes is 1.6 mm to 0.038 mm. The sieves may be placed on a shaker to achieve a consistent amount of shaking. The amount of material that is collected on each sieve is weighed and expressed as a percentage of the total weight. Further details are given in (Dichter, 1978) in Appendix 1.

This method can also be used to detect gross contamination with stalks, stones, string, cigarette ends, leaves etc as these are retained on the larger aperture sieves and can be examined, recorded or weighed.

Filth test

This is a modified method that allows detection of insect parts, rodent hairs or ground faeces in milled spices or flours. The sample of food is mixed with petrol and thoroughly stirred. The insect parts, etc. are preferentially wetted by the petrol and when the suspension of particles settles, these may be seen floating on the surface of the petrol. If required they may be filtered through a filter paper and examined or identified.

Sodium benzoate measurement

Although it is possible to measure the amount of sodium benzoate in a food by measuring the benzoic

acid content, this is a fairly complex method that requires laboratory facilities and it is unlikely to be routinely done by a small scale producer. The method is described in publications by Board (1988) and Egan et al (1981) in Appendix 1.

Sodium metabisulphite measurement

The amount of sulphur dioxide that is produced from sodium metabisulphite is approximately two thirds. For example if 1.5 g of sodium metabisulphite is added to one litre of juice it will form 1 g of sulphur dioxide. (la per litre = 0.001%. This is equivalent to 1000 ppm). The amount of sulphur that is required to produce sulphur dioxide in a sulphur cabinet is usually only estimated approximately because of the large number of variables that influence the absorption of sulphur dioxide by fruits. As an approximate estimate, 350400 g of sulphur can be used per 100 kg of fresh fruit.

Although it is possible to measure the sulphur dioxide content of a food item, this requires relatively sophisticated laboratory equipment and is not usually done by small scale producers. A method is described by Board (1988) in Appendix 1.

Starch gelatinization measurement (modified 'Falling Number' method)

1. **100 g of flour is mixed with 900 g of hot water in a pot.**
2. **The pot is heated until the flour mixture has gelatinised.**
3. **The mixture is poured into a 1 litre measuring vessel.**
4. **The measuring vessel is stood in hot water.**

5. **A steel ball is dropped into the mixture and the time to drop 200 ml recorded.**
6. **The time (in seconds) is compared against the standard batch.**

Sugar measurement using soluble solids content measurement (by refractometer)

Fruit jams, juices, sauces, confectionery, etc. contain sugar as the main soluble solid. For these products the sugar content can be measured directly using a refractometer. Although this equipment is relatively expensive for a small scale producer, it does give an accurate measurement of sugar concentration which is a vital control point for many products. Two types of refractometers are available: the bench type (or 'Abbe' refractometer) and a hand held type (Figure 46: A hand-held refractometer). For quality control purposes the hand held type is cheaper and it is usually sufficiently accurate.

The method involves taking a small sample of the food and placing it on the lower glass prism of the instrument. The upper prism is then closed and the refractometer is held against the eye, pointing in the direction of a window or bright light. It is focused until the scale can be read against a clearly defined division between black and orange colours. The reading is recorded as degrees Brix which corresponds to % sucrose.

Sugar measurement using hydrometry

Simple sugar syrups may also be measured using hydrometry. The hydrometers are similar to those described for salt, but they are calibrated for sugar (sucrose). The method used is the same as that described for salt and the scale is read as % sucrose. The samples should be at the reference temperature (usually 20C) for the hydrometer.

Sugar measurement using temperature

The sugar content of products such as jams and confectionery can be estimated in a less accurate way by measuring the temperature of boiling. As the sugar content increases the temperature of boiling also increases (Table 10). Note that the boiling temperature also changes according to the amount of invert sugar or glucose syrup in the boiling mixture and experience of making the product is needed before using boiling temperature as a control measure. The boiling point also changes according to height above sea level and this should be checked if a producer is operating in a mountainous region.

Table 10: Boiling temperatures of different sugar syrup concentrations

Sugar concentration (% sucrose)	Boiling point (C)
40	101.4
50	102
60	103
711	105.5

A special thermometer that reads up to 150C is required and the bulb of the thermometer should be protected by a metal casing to protect it against breaking ([Figure 47: A thermometer suitable for measuring the high temperatures in jam boiling]). In general mercury thermometers should not be used in food premises.

A crude estimate of the solids content of jam and confectionery products may be made by placing a sample on a jar lid which is floating in cold water and noting the texture of the product after it has cooled to see if a firm gel is formed. With experience this may be used as a simple check to ensure that products have been boiled to the correct consistency, but a more accurate measurement using a refractometer is recommended to ensure uniform product quality. A summary of the methods and expected results is given in Table 11.

Water absorption measurement (flour)

1 100 g of flour is weighed into a small mixer.

2 Water is slowly added from a burette until a standard dough is made. This is judged by the processor by adding water until it 'feels right'.

3 The amount of water added is recorded.

New batches of flour are tested alongside the existing material. This can be used as a comparative test to indicate wrong grade of flour.

Yeast activity measurement

1 A 5% suspension of fresh yeast is made.

2 3 g of flour is weighed into a pot.

3 1.8 g of suspension is added and mixed with a spoon.

4 The mass is moulded into a ball using the hand and dropped into a narrow 200 ml beaker containing 150 ml of water.

5 The beaker is placed in a water bath at room temperature (25-30C).

6 The time from placing in beaker until final break-up of the ball is the fermentation time.

Table 11: Simple tests for sugar boiling

Approx Temperature (C)	Test	Name	Result
103	A	Thread	Thin strands
105	B	Small pearl	Forms small droplets
105	C	Jam set	Forms a strong gel
106	B	Large pearl	Forms large droplets

111	B	Feather	Forms hard feathery strands
116	B	Small ball	Forms soft ball
120	B	Large ball	Forms hard ball
129	B	Light crack	Forms thin sheet
133	B	Medium crack	Sheet forms, slightly brittle
143	B	Hard crack	Sheet forms rapidly
180	B	Caramel	Brown brittle sheet forms

Methods:

A - Place a sample of cooked syrup between two wetted fingers and open them.
B - Dip a spatula in water and then in the cooked syrup, return it to cold water.
C - Place a sample on a jar lid in cold water, test by feeling after it has cooled.
(Adapted from Lees and Jackson, 1985. see Appendix 1)

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Appendix 1

Contents - Previous - Next

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Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Appendix 2

Contents - Previous

REFERENCE DOCUMENTS (BAKERY PRODUCTS)

Considerable work has been done to develop standardised testing of bakery products and a selection of commercial testing methods and documentation is included here as examples. Each may be modified for use with other food commodities.

Suggested tests for major raw materials

Scoring systems for commercial bread assessment

Scoring systems are designed to give numerical values to various properties of the bread, weighted in favour of the features that are important to the company. A typical system might be:

4 points for external appearance
5 points for crumb colour
8 points for crumb cell structure
8 points for crumb firmness

Bread assessment sheet

Loaf Characteristics: shape, volume, crust colour, crumb colour, evenness of crumb cells, fineness of cell structure, size of the cells, crumb firmness, crumb springiness, stability and strength, eating quality:- flavour and aroma, other faults (ea. contamination, wrong weight)

Bread is assessed and given a score so that the reason for score can enable the bakery to see where it does not compare favourably against competitors.

<u>Crumb Firmness</u>: **Customers rate freshness as most important characteristic of sliced and wrapped bread. The most common method of checking the freshness is a squeeze test. Crumb firmness is affected by age of the loaf; size of the loaf, degree of baking and storage conditions.**

<u>Crumb Springiness</u>: **While measuring crumb firmness it is easier to measure crumb recovery, i.e. degree of crumb springiness or resilience. This is important in separating soft, soggy bread from soft but resilient bread.**

Scores are given as follows:

> 50% recovery - 8 points
45-50% recovery - 6 points
40-45 % recovery - 4 points
35-40% recovery - 2 points

<u>Crust Colour</u>: **assessed against colour standards as follows:**

5 points - golden brown
2 points - pale crust
0 points - burnt crust

Crumb Colour: should be uniformly white; 12 points for colour and evenness.

Crumb Stability: 10 points for crumb stability.

Crumb Structure: size and shape of cells; thickness of the cell walls; and the evenness of the cells. Judgement of these characteristics relies heavily on experience and knowledge of bread variety, but it may assist producer in correcting faults. 20 points for crumb structure.

Loaf volume

Judgement of test loaves:

The general judgement of bread concerns the effects of changes in all parts of the baking process on the quality of the loaf. Test loaves should be judges for:

Flavour and Aroma (Note whether flavour and aroma "normal" or "unusual")

Volume

External shape, appearance & colour

Oven break

Crumb colour

Crumb texture

Crumb softness and strength

In order to judge crumb quality it is necessary to cut the loaf accurately across the middle, using a very sharp knife and taking care to produce a perfectly flat surface. Apart from volume, it is not really practicable to evaluate these aspects of quality without the use of judgement and experience and simple reproducible numbers cannot be quoted. It is always necessary to compare the test loaf with the control loaf and with experience, it is possible to place the test loaf in one of the following categories:

Much better than control +3

Better than control +2

Slightly better than control + 1

Equal to control 0

Slightly poorer than control -1

Poorer than control -2

Much poorer than control -3

An overall marking for the general quality of the loaf, in comparison with the control may thus be produced by adding the numbers. Such a system of marking is only satisfactory when operated by one individual as he/she will emphasise certain aspects more than others. However, if carefully used a system of this sort may be of great value within a bakery.

Volume: This is the one attribute of a loaf which may be measured accurately but due to the irregular

shape care is needed. The method is described in Chapter 3 (loaf volume measurement). Lack of volume generally indicates the use of a weak flour, or one low in enzyme activity. A very strong flour may also produce a loaf of small volume and this would indicate the need of a longer fermentation period, during which the gluten would become ripened and so more extensible.

Contents - Previous