
Quality Control in Food Industry

Quality control is the sum of all those controllable factors that ultimately influence positively or negatively the quality of the finished product e.g. selection of raw materials, processing methods, packaging, methods of storage distribution etc. Quality is defined as any of the features that make something what it is or the degree of excellence or superiority. The word "quality" is used in various ways as applied to food.

Quality product to the salesman means one of high quality and usually at an expensive nature e.g. champagne is considered a quality as compared to fish and chips. Likewise for fresh produce, the word "quality" refers to the attributes of the food which make it agreeable to the person who eats it. This involves positive factors like colour, flavour, texture and nutritive value as well as the negative characteristic such as freedom from harmful microorganisms and undesirable substances.

The term control does not imply that a poor raw material can be converted into a good finished product. In food processing, the general rule is that the effective methods must be carefully applied to conserve the original qualities of the raw materials. Processing cannot improve the raw material. The aim of quality control is to achieve as good and as consistent a standard of quality in the product being produced as is compatible with the market for which the product is designed.

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".

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.

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.

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.

ANALYSING FOOD PROCESSES

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.

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 microorganisms). 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 microorganisms, biological, chemical or physical contaminants. 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.
- Study the effect of the process on levels of contamination and assess the probability of microorganisms 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, 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.

This should be considered in relation to microorganisms of concern. Stages in the process that destroy, reduce or allow survival of microorganisms should be evaluated.

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” 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.

DESIGN OF BUILDINGS 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. 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.

Location of the Building

The location of the building is very important but is often ignored at the outset. 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.

Appearance of the Building

The external appearance of the building is a key factor that can influence customers to believe that the company has good management. 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 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 storeroom. 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. 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.

Equipment and Layout

Poor equipment layout can be blamed for many quality problems in food factories.

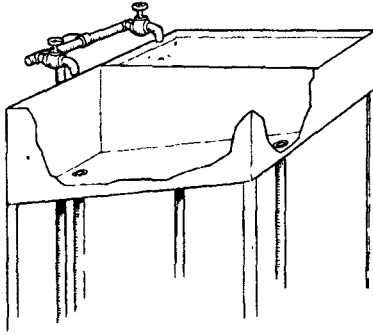


Figure 1. Double tank water purification system

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.
- 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.

SANITATION AND HYGIENE

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 microorganisms. 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. Manufacturers should investigate which types are available locally and consult suppliers to find the best type for their process.

Chlorinated Water

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. 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 1 shows the dilutions needed to give different chlorine concentrations.

Table 1. 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.

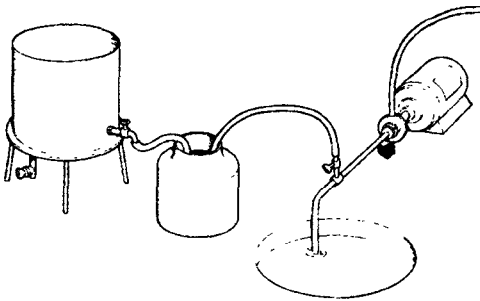


Figure 2. A typical chlorine dosing installation

Although chlorine has the great advantage of killing a wide variety of microorganisms, 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.

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.

Cleaning Schedules

The overall cleanliness of a food processing unit, however small, can have a major impact on the quality of finished products. 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.

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.

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 responsible 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 and microbiological 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 increasingly 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 relevant 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 relevant 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.

SIMPLE METHODS FOR QUALITY CONTROL

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.

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 as this does not tell you the amount of acid present.

The method involves the following steps:

- take a 10 ml sample of liquid food or 10 g of solid food
- if solid, the food should be liquidised to a fine pulp
- mix the sample with 90 ml of distilled water, making sure that it is completely mixed
- add about 0.3 ml of an indicator solution
- fill a burette 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.
- 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

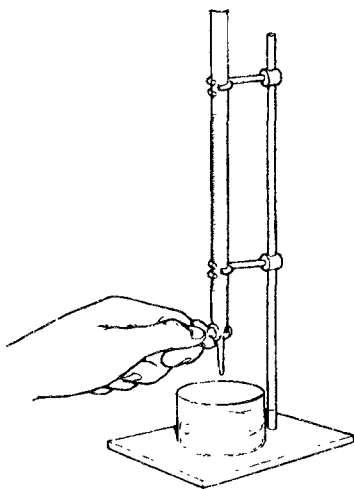


Figure 3. A burette used for titration

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

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'. This is supplied with a number of discs of coloured glass that are calibrated for different chlorine levels.

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.

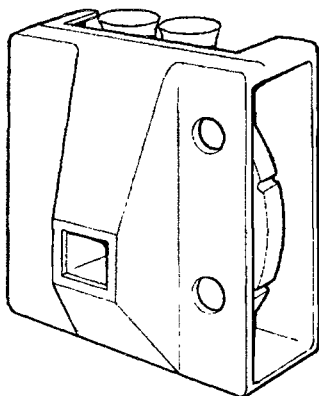


Figure 4. A comparator, used to test chlorine levels in water.

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 than this weight. This should be routinely checked by taking regular samples of filled containers and placing them on a scale. On the other side of the scale there is the heaviest empty container from a batch 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 unnecessarily 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

- 100 grams of flour is weighed onto a flat surface.
- Flour is flattened using a ruler.
- Flour is examined after two minutes for evidence of pimpling.

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 container has the expected capacity;
- that the neck is properly formed and will allow the lid to fit properly;
- that the container is vertical to prevent it breaking in a filling machine, and
- 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.

Weigh a dried container and then fill it to the top with distilled water at 20°C. 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 Gauge

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 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.

Partial Vacuum

The partial vacuum in hot-filled glass jars may be measured using a Bourdon tube vacuum gauge. 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. 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. 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

- Weigh 10 + 0.01 g of flour and place in a basin.
- Add 6ml of water to the basin, (5 ml will be sufficient for weak flour).
- 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.
- Replace the dough in the basin and cover it with water.

Leave for a time, at least 10 minutes, preferably 45-60 minutes.

- 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.
- When all the starch has been removed the wash water will run clear and the remaining gluten will be free from lumps.
- Remove the excess water with blotting paper.
- Weigh the wet gluten and record this as a percentage of the flour weight.
- The gluten may be dried in an oven at 103°C to determine dry gluten.

Label Measurement

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

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 100°C for 5 hours (or 104°C 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:

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

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.

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 8-14). 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. In general bench models are more accurate than portable types, although newer equipment has reduced this difference.

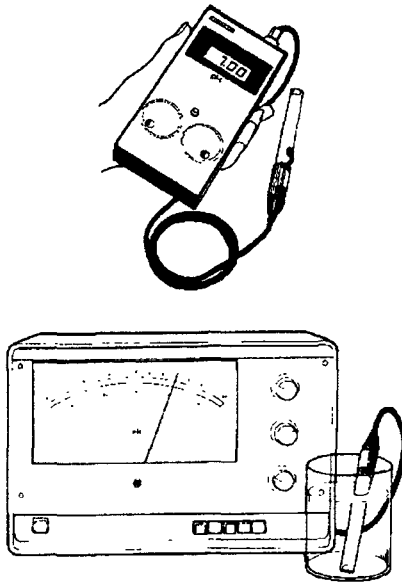


Figure 5. Bench mounted and portable pH meters

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 20-30°C) 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 20-30°C) 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 'stand by' 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 watertight 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. 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. 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 20°C) 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

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. 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.

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. (1a 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.

Starch Gelatinisation Measurement

- 100 g of flour is mixed with 900 g of hot water in a pot.
- The pot is heated until the flour mixture has gelatinised.
- The mixture is poured into a 1 litre measuring vessel.
- The measuring vessel is stood in hot water.
- A steel ball is dropped into the mixture and the time to drop 200 ml recorded.
- The time (in seconds) is compared against the standard batch.

Sugar Measurement

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.

Table 2. Boiling temperatures of different sugar syrup concentrations

Sugar concentration (% sucrose)	Boiling point (°C)
40	101.4
50	102
60	103
71.1	105.5

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 and a hand held type. 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.

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 for the hydrometer.

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. 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.

A special thermometer that reads up to 150°C is required and the bulb of the thermometer should be protected by a metal casing to protect it against breaking. 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.

Table 3. 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

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 3.

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