

CONTROLLING THE MICROBIOLOGICAL QUALITY OF FOODS

QUALITY AND CRITERIA

Quality as the 'degree of excellence' possessed by a product, that is to say how good it is at serving its purpose. In terms of the microbiology of foods, quality comprises three aspects:

- (1) Safety. A food must not contain levels of a pathogen or its toxin likely to cause illness when the food is consumed.
- (2) Acceptability shelf-life. A food must not contain levels of microorganisms sufficient to render it organoleptically spoiled in an unacceptably short time.
- (3) Consistency. A food must be of consistent quality both with respect to safety and to shelf-life. The consumer will not accept products which display large batch-to-batch variations in shelflife and is certainly not prepared to play Russian roulette with illness every time he or she eats a particular product.

Regulatory bodies and the food industry are the two groups most actively interested in determining and controlling the microbiological quality of foods. The regulatory authorities must do so to fulfill their statutory responsibility to protect the public from hazardous or inferior goods. Commercial companies, both food producers and retailers, also have a major interest, since their association with products that are consistently good and safe will protect and enhance their good name and their market.

To distinguish food of acceptable quality from food of unacceptable quality requires the application of what are known as microbiological criteria. Three different types of microbiological criterion have been defined by The International Commission on Microbiological Specifications for Foods (ICMSF).

The ICMSF have also specified what should be included in a

microbiological criterion as set out below:

(1) A statement of the food to which the criterion applies. Clearly foods differ in their origin, composition, and processing; will present different microbial habitats; and will therefore pose different spoilage and public health problems.

(2) A statement of the micro-organisms or toxins of concern. These may cover both spoilage and health aspects, but decisions on what to include must be realistic and based on a sound understanding of the microbial ecology of the food in question.

(3) Details of the analytical methods to be used to detect and quantify the micro-organisms/toxins. Preferred methods for standards or specifications would be those elaborated by international bodies, although less sensitive or less reproducible methods may be used for simplicity and speed in confirming compliance with guidelines.

(4) The number and size of samples to be taken from a batch of food or from a source of concern such as a point in a processing line.

(5) The microbiological limits appropriate to the product and the number of sample results which must conform with these limits for the product to be acceptable (n, c, m, and M, see Section 11.2). In this regard, it should be remembered that for certain foodborne pathogens such as *Staphylococcus aureus* or *Clostridium perfringens*, their mere presence does not necessarily indicate a hazard and specification of some numerical limits is necessary.

Micro-organisms are rarely distributed uniformly throughout a food, nor in fact are they usually distributed randomly. When microorganisms are dispersed in a food material in the course of its production, some may die, some may be unable to grow and others may find themselves in microenvironments in which they can multiply. The resulting distribution, containing aggregates of cells, is described as a contagious distribution.

SAMPLING SCHEMES

The sampling scheme most commonly applied in the microbiological testing of foods is that of sampling for attributes. It makes no assumption about the distribution of micro-organisms within the batch of food and is therefore particularly suited to situations where we have no knowledge of this; for example with imported foods at their port of entry.

Two-class Attributes Plans

In an attributes sampling scheme analytical results are assigned into classes; in the simplest type, the two-class scheme, samples are classified as acceptable or defective depending on the test result. A sample is described as defective if it is shown to contain more than a specified number of organisms or, in cases where a presence or absence test is applied, the target organism is detected.

Three-class Attributes Plans

Three-class attributes sampling plans introduce a further category and divide samples into three classes: acceptable, marginally acceptable, and unacceptable. Use of this extra classification of marginally acceptable means that they are not used with presence or absence tests but only with microbiological count data.

QUALITY CONTROL USING MICROBIOLOGICAL CRITERIA

In the 1970s in Oregon in the United States standards were introduced governing the microbiological quality of ground meat in retail stores. After they had been in force for a few years an enquiry was conducted into their effect. The principal conclusion was that, although there was felt to have been a general improvement in sanitation and handling, the standards had produced no significant change in quality. There was no evidence that the bacterial load on ground meat or the risk of foodborne illness had been reduced and, on the debit side, significant costs had been incurred as a result of rejection of material not meeting the standard and through the expense of microbiological testing.

The most effective way of controlling quality is through intervention at source, during the production process. On its own, any amount of testing

will not improve product quality one jot, to do this requires action where the factors which determine quality operate, namely in the processing and supply chain itself.

CONTROL AT SOURCE

The traditional approach to control of microbiological quality at source has relied upon a combination of a well-trained workforce, rigorous inspection of facilities and supervision of operations, coupled with microbiological testing, not only of finished product, but also of ingredients, product in process, equipment, the environment, and personnel.

Training

Food handlers should be trained in the basic concepts and requirements of food and personal hygiene as well as those aspects particular to the specific food-processing operation. The level of training will vary depending on the type of operation and the precise job description of the employee, however some form of induction training with regular updating or refresher courses is an absolute minimum. Training should give food handlers an understanding of the basic principles of hygiene, why it is necessary, and how to achieve it in practice. A core curriculum for any such course should emphasize:

1. Micro-organisms as the main cause of food spoilage and foodborne illness and the characteristics of the common types of food poisoning.
2. How to prevent food poisoning through the control of microbial growth, survival or contamination.
3. Standards of personal hygiene required of food handlers. These are principally to avoid contamination of food with bacteria the food handler may harbour as part of the body's flora, e.g. *Staph. aureus*, *Salmonella* or that they may bring in with them from the outside world, e.g. *Listeria*, *B. cereus*.

4. Principles of the handling and storage of foods such as the correct use of refrigerators and freezers, the importance of temperature monitoring, the need for stock rotation and the avoidance of cross-contamination.
5. Correct cleaning procedures and the importance of the 'clean-as-you-go' philosophy.
6. Knowledge of the common pests found in food premises and methods for their exclusion and control.
7. An introduction to the requirements of current food legislation.

Facilities and Operations

The environment in which food processing is conducted as an important factor in determining product quality. The premises should be of sufficient size for the intended scale of operation and should be sited in areas which are free from problems such as a particular pest nuisance, objectionable odours, smoke or dust. The site should be well accessed by metalled roads and have supplies of power and potable water adequate to the intended purpose. Particular attention should also be paid to the provision of facilities for the efficient disposal of processing wastes.

Buildings must be of sound construction and kept in good repair to protect the raw materials, equipment, personnel and products within, and to prevent the ingress of pests. The grounds surrounding the plant should be well maintained with lawns cut regularly and a grass-free strip of gravel or tarmac around the buildings. Well-tended grounds will not only prove aesthetically pleasing but will help in the control of rodent pests. Landscaping features such as ponds are not advisable since they may encourage birds and insects.

It is important that the buildings provide a comfortable and pleasant working environment conducive to good hygienic practices. They should be well lit, well ventilated and of sufficient size to maintain the necessary separation between processes that could give rise to crosscontamination.

Features such as control of temperature and relative humidity and a positive pressure of filtered air may be required in some process areas for the benefit of both personnel and product.

Equipment

Equipment and its failings can be a source of product contamination. The main objectives of the design of hygienic food-processing equipment are to produce equipment that performs a prescribed task efficiently and economically while protecting the food under process from contamination. There is general agreement on the basic principles of hygienic design, as outlined by a number of bodies.

1. All surfaces in contact with food should be inert to the food under conditions of use and must not yield substances that might migrate to or be absorbed by the food.
2. All surfaces in contact with the food should be microbiologically cleanable, smooth and non-porous so that particles are not caught in microscopic surface crevices, becoming difficult to dislodge and a potential source of contamination.
3. All surfaces in contact with food must be visible for inspection, or the equipment must be readily dismantled for inspection, or it must be demonstrated that routine cleaning procedures eliminate the possibility of contamination.
4. All surfaces in contact with food must be readily accessible for manual cleaning, or if clean-in-place techniques are used, it should be demonstrated that the results achieved without disassembly are equivalent to those obtained with disassembly and manual cleaning.
5. All interior surfaces in contact with food should be so arranged that the equipment is self-emptying or self-draining. In the design of equipment it is important to avoid dead space or other conditions which trap food and may allow microbial growth to take place.

6. Equipment must be so designed to protect the contents from external contamination and should not contaminate the product from leaking glands, lubricant drips and the like; or through inappropriate modifications or adaptations.
7. Exterior surfaces of equipment not in contact with food should be so arranged to prevent the harbouring of soils, microorganisms or pests in and on equipment, floors, walls and supports. For example, equipment should fit either flush with the floor or be raised sufficiently to allow the floor underneath to be readily cleaned.
8. Where appropriate, equipment should be fitted with devices which monitor and record its performance by measuring factors such as temperature, time, flow, pH, weight.

Cleaning and Disinfection

In the course of its use, food processing equipment will become soiled with food residues. These may impair its performance by, for instance, impeding heat transfer, and can act as a source of microbiological contamination. Hygienic processing of food therefore requires that both premises and equipment are cleaned frequently and thoroughly to restore them to the desired degree of cleanliness. Cleaning should be treated as an integral part of the production process and not regarded as an end-of-shift chore liable to be hurried or superficial.

What appears to be clean visually can still harbour large numbers of viable micro-organisms which may contaminate the product. Cleaning operations in food processing have, therefore, two purposes:

- (i) physical cleaning to remove 'soil' adhering to surfaces which can protect micro-organisms and serve as a source of nutrients; and
- (ii) microbiological cleaning, also called sanitizing or disinfection, to reduce to acceptable levels the numbers of adhering microorganisms which survive physical cleaning.

These are best accomplished as distinct operations in a two-stage

cleaning process, although combined detergent/disinfectants are sometimes used for simplicity and where soiling is very light.

There are three main types of surfactant, classified according to the nature of the hydrophilic portion of the molecule:

(i) anionic - in these, which include soaps, alkyl and alkylbenzene sulfonates and alcohol sulfates, the hydrophilic portion is a negatively charged ion produced in solution. They are incompatible with the use of quaternary ammonium compounds (QUATs) which are positively charged;

(ii) non-ionic - made by condensing ethylene oxide on to the polar end of a fatty acid, fatty alcohol or alkyl phenol;

(iii) cationic - quaternary ammonium compounds (QUATs) which have a positive charge in solution and are used mainly for their bacteriostatic and bacteriocidal activity rather than their cleaning properties.

Many micro-organisms will be removed along with the soil in the course of cleaning, but many may remain on an apparently clean surface. It is therefore necessary to disinfect equipment after cleaning. Six types of chemical disinfectant are most commonly used in food processing:

- (1) chlorine and chlorine compounds
- (2) iodophors
- (3) quaternary ammonium compounds (QUATs)
- (4) biguanides
- (5) acid anionic surfactants
- (6) amphoteric surfactants

THE HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) CONCEPT

This has improved on traditional practices by introducing a more systematic, rule-based approach for applying our knowledge of food microbiology to the control of microbiological quality.

HACCP itself has evolved since its first formulation and has been the subject of considerable international discussion and debate. In recent years however national and international bodies seem to have settled on an agreed definition based on seven essential principles of a HACCP system:

1. Conduct a hazard analysis.
2. Determine the Critical Control Points (CCPs).
3. Establish critical limits.
4. Establish a system to monitor control of the CCP.
5. Establish corrective action to be taken when monitoring indicates that a particular CCP is not under control.
6. Establish procedures to verify that the HACCP system is working effectively.
7. Establish documentation concerning all procedures and records appropriate to these principles and their application.

Hazard Analysis

Hazard Analysis determines which hazards could pose a realistic threat to the safety of those consuming the product and must therefore be controlled by the production process.

(i) raw materials or ingredients that may contain micro-organisms or metabolites of concern, the likely occurrence of these hazards and the severity of their adverse health effects;

(ii) the potential for contamination at different stages in processing:

(iii) intermediates and products whose physical and chemical

characteristics permit microbial growth and/or survival, or the production and persistence of toxic metabolites; and

(iv) measures that will control hazards such as process steps which are lethal or bacteriostatic.

Identification of Critical Control Points (CCPs)

Once the hazard analysis has produced a list of the potential hazards, where they could occur, and measures that would control them, critical control points (CCPs) are identified. A CCP is defined as a location, step or procedure at which some degree of control can be exercised over a microbial hazard; that is, the hazard can be either prevented, eliminated, or reduced to acceptable levels. Loss of control at a CCP would result in an unacceptable risk to the consumer or product.

Establishment of CCP Critical Limits

For each of the CCPs identified, criteria must be specified that will indicate that the process is under control at that point. These will usually take the form of critical limits (with tolerances where appropriate) necessary to achieve control of the hazard. Criteria may include:

(i) physical parameters such as temperature, time, humidity, quantity of product in a pack, dimensions of can seams, or depth of product in trays to be chilled;

(ii) chemical parameters such as pH in fermented or acidified foods, a, in intermediate-moisture foods, salt concentration, available chlorine in can cooling water, or level of preservative;

(iii) sensory information such as texture, appearance, or odour; or,

(iv) management factors such as the correct labelling of products with instructions for use and handling, or efficient stock rotation.

Monitoring Procedures for CCPs

Crucial to the application of criteria at CCPs is the introduction of monitoring procedures to confirm and record that control is maintained.

It is important to remember that the assurance given by monitoring procedures will only be as good as the methods used and these too must be regularly tested and calibrated.

Protocols for CCP Deviations

When routine monitoring indicates that a CCP is out of control there should be clearly described procedures for its restoration, who is responsible for taking action and for recording the action taken. In addition to measures to restore the process, it should also prescribe what should be done with product produced while the CCP was out of control.

Verification

Verification is the process of checking that a HACCP plan is being applied correctly and working effectively. It is an essential feature of quality control based on HACCP and is used both when a system is first introduced and to review existing systems. Verification uses supplementary information to that gathered in the normal operation of the system and this can include extensive microbiological testing. To verify that criteria or critical limits applied at CCPs are satisfactory will often require microbiological and other, more searching, forms of testing. For example, microbial levels may need to be determined on equipment where day-to-day monitoring of cleaning procedures is based on visual inspection alone, or the precise lethality of a prescribed heat process may have to be measured. In normal operation, only limited end product testing is required because of the safeguards built into the process itself, but more detailed qualitative and quantitative microbiological analyses of final product and product-in-process may be required in a verification programme. Supplementary testing must be accompanied by a detailed on-site review of the original HACCP plan and the processing records.

Record Keeping

The HACCP scheme should be fully documented and kept on file. Documentation should include details of the HACCP team and their responsibilities; material from the Hazard Analysis such as the product

description and process flow diagram; details of the CCPs - the hazards associated with them and critical limits; monitoring systems and corrective action; procedures for record keeping and for verification of the HACCP system. This should be accompanied by associated process records obtained during operation of the scheme. It will also include material such as documentation to verify suppliers' compliance with the processor's requirements, records from all monitored CCPs, validation records and employee training records.