IN-PROCESS QUALITY CONTROL

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Contents

Summary

In-process quality control allows the producer to follow all changes that occur during applied technological procedures. It gives the producer security that the finished product fulfills all quality requirements, most of all that the product should be safe. To control technological procedures, many systems have been elaborated. The Good Manufacturing Practice (GMP) and the Quality Management Program (QMP) were developed and successfully applied in many food plants. These systems were further developed into more effective ones—the HACCP (Hazard Analysis Critical Control Points) system. These systems are utilized to prevent disastrous events resulting from microbiological, chemical, and physical hazards.

Specific aspects of in-process control include the control systems applied during the production of individual foods. Such systems depend on raw materials and finished food products. The greatest attention is paid to the safety of produced food, from the microbiological and the chemical points of view. All food components that are important nutritionally, and sensorially, especially those that are decomposed during food production, are followed. For these purposes a wide spectrum of methods may be applied.

1. Introduction

Food processing may induce changes in food composition and in other properties of raw material. Such changes may improve or deteriorate the quality of the end product. During the technological procedures, when native raw material is treated, biochemical (post harvest or post slaughter) reactions can continue, especially under favorable conditions. When biochemical reactions stop, mostly from applied heat treatment, it leads to the inactivation of enzymes. However, other chemical reactions may continue. For this reason it is important to follow quality changes during the whole technological procedure. On this basis, producers are able to follow analytically the critical technological stages, and can improve their technological procedures. Producers have incorporated such an activity in their GMP (good manufacturing practice) and QMP (quality management program). For food safety, potential microbial or chemical contamination should be avoided. For quality assurance and food safety, the systems HACCP (Hazard Analysis and Critical Control Point) are used. These systems are utilized to prevent disastrous events resulting from microbiological, chemical, and physical hazards. The HACCP incorporates the assessment of risk associated with growing and harvesting raw materials; ingredients; and with processing, manufacturing, distribution, marketing preparation, and consumption of food. Critical control points, required to control identified hazards, also are determined. This system establishes critical limits that must be met at each control point, and procedures to monitor critical control points. It is necessary to establish the corrective action to be taken when there is a deviation identified by monitoring critical control points. Effective recordkeeping systems that document the HACCP plan, and provide verification that the HACCP system is working correctly, are also included in the system.

2. General Aspects of In-Process Control

As already mentioned, many reactions take place during the technological procedures applied. Some of them may be desirable (they can improve the nutritional, sensory, and hygienic quality of products); others are undesirable (they can lower all above-mentioned parameters). For this reason it is necessary to follow the changes of food quality and food safety during the whole technological procedure.

2.1. Aims of In-Process Control

The main aim of in-process control is to optimize the whole applied technological procedure. Speaking about optimization, we have in mind the regulation of all technological operations in such a way that guarantees a product of the highest quality as measured by all quality criteria. In this respect attention must be paid to the safety of

produced food. In-process control can detect the critical point of the technological procedure, and in this way help the producer control only such parts of technological procedures where real danger exists for lowering the total quality of produced foods.

2.2. Good Manufacturing Practice (GMP)

GMP is defined as those procedures in a food processing plant that consistently yield products of acceptable quality suitably monitored by laboratory and in-line tests. A code of GMP must define details of the processes necessary to achieve this goal, such as times, temperature, details of equipment, plant layout, disinfection (sanitation), hygiene practices, and laboratory tests.

The codes of the GMP have been produced by a variety of organizations, including national regulatory bodies; international organizations, such as the Codex Alimentarius Commission; and trade associations and professional bodies. The codes can be used by manufacturers as the basis for producing good quality products, but may also be used by inspectors from regulatory bodies.
While codes can be very useful, a frequent limitation is that as they were developed to be widely applicable, they tend to be imprecise. This leads to the use of phrases such as "appropriate cleaning procedures," without specifying what these may be; "cleaning as frequently as possible," without specifying a required frequency. They also often fail to identify the most important requirements affecting food quality, and those of lesser importance. As a result, someone conducting supervision or inspection of an operation is left uncertain as to what is specifically required to ensure that the operation is conducted in compliance with GMP. This sort of information is often only available based on a detailed analysis of an individual processing operation. For this reason, the food industry has replaced the GMP with the more sophisticated HACCP system.

2.3. HACCP (Hazard Analysis and Critical Control Points)

Approaches in the food industry based on Good Manufacturing Practices (GMP) are being largely replaced by application of the HACCP concept. This has improved the traditional practices by introducing a more systematic, rule-based approach for applying our knowledge of the food microbiology of physical and chemical factors affecting food safety or acceptability. It should be remembered that HACCP is primarily a preventive approach to quality assurance, and as such it is not only a tool to control quality during processing but can also be used to design quality into new products during their development. Although there is some variation in the approach adopted, it is internationally agreed that implementation to produce a fully documented HACCP scheme proceeds in seven stages.

2.3.1. Hazard Analysis

In the first stage, the HACCP team produces a full description of the product and its intended use, and conducts a detailed evaluation of the entire process to produce a flow diagram. This must cover all process steps under the manufacturer's control, but may also extend beyond this, from before the raw materials enter the plant to the product's eventual consumption. The flow chart must contain details of all raw materials used; all

processing, holding, and packaging stages; a complete time-temperature history; and details of factors such as pH and a_w, that will influence microbiological growth and chemical change in products. Additional information covering plant location, design, and capacity of the process equipment and storage facilities, and cleaning and sanitation procedures are also necessary to assess the possible risk of contamination. Once completed, it is important that the accuracy of the final document be verified in a separate assessment, during which the process is inspected using the flow diagram and guide.

Hazard analysis should determine where hazard might arise by identifying:

- raw materials or ingredients that may contain microorganisms or metabolites of concern, or other contaminants
- the potential for contamination at different stages in processing
- intermediates and products whose physical and chemical characteristics permit microbiological growth and/or survival, and
- measures that will control hazards such as process steps that are lethal or bacteriostatic.

2.3.2. Identification of Critical Control Points (CCPs)

Once hazard analysis has shown a CCP defined as a location, step, or procedure at which some degree of control can be exercised over a microbiological or other hazard, the hazard can either be prevented, eliminated, or reduced to acceptable levels. Loss of control at a CCP would result in an unacceptable risk to the product and/or consumer.

A raw material could be a CCP if it is likely to contain a microbiological or other hazard, and if subsequent processing, including correct consumer use, will not guarantee its control. Specific processing steps such as cooking, chilling, freezing, or some feature of formulation may be a CCP, as could aspects of plant layout, cleaning, and disinfection procedures, or employee hygiene. It is clear that different hazards will be controlled by different CCPs (heat treatment, chilling, and so on).

2.3.3. Establishment of CCP Criteria

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 the critical limits (with tolerance where appropriate) necessary to achieve control of the hazard. Such criteria may include physical parameters (temperature, time, humidity, quantity of product in a pack, dimensions of can seams, or depth of product when chilled), chemical parameters (pH, a_w, salt concentration, available chlorine in can-cooling water, or level of preservatives), sensory information (texture, appearance, odor, and so on), and management factors (correct labeling of products with instruction for use and handling, or efficient stock rotation).

2.3.4. 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.

To achieve on-line control of a processing operation, monitoring procedures should, when possible, be continued, and provide real time measurement of the status of a CCP. If continuous monitoring is not possible, it should be of a frequency sufficient to guarantee detection of deviations from critical limits. The errors involved in periodic sampling should be taken into account when setting those limits.

Records should be kept of the performance of CCPs. These will assist in process verification and also be analyzed for trends that could lead to a loss of process control in the future.

2.3.5. Protocols for CCP Deviations

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

2.3.6. Recordkeeping

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 the critical limits; monitoring systems and corrective actions; and procedures for recordkeeping and for verification of the HACCP system. The documentation should be accompanied by related process records obtained during operation of the scheme. It should also include material such as documentation to verify supplier's compliance with processor's requirements, records from all monitored CCPs, validation records, and employee training records.

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Bibliography

Amado R. and Battaglia R., eds. (1997). *Authenticity and Adulteration of Food: The Analytical Approach.* Winterthur: Sailer. [The analytical approach for the determination of food authenticity and adulteration of foods.]

Arthey D. and Ashurst P.R. (2000). *Fruit Processing: Nutrition, Products, and Quality Management.* Gaithersburg: Aspen Publ., Inc. [Deals with fruit technology and its influence on the composition of processed food products and quality control.]

Clydesdale F.M. (1996). *Food Additives: Toxicology, Regulation and Properties.* Boca Raton, FL: CRC Press. [The book gives detailed information on properties of food additives, their toxicology, and the regulation of their use in the food industry.]

Davídek J., ed. (1995). *Natural Toxic Compounds of Foods: Formation and Changes During Processing and Storage.* Boca Raton, FL: CRC Press. [Gives an overview of natural toxic compounds and the influence of technological procedures on their content in processed foods.]

Davídek J., Velíšek J. and Pokorný J. (1990). *Chemical Changes During Food Processing.* Amsterdam: Elsevier. [Presents an overview of chemical changes during food processing and storage of foods.]

FAO/WHO (1997). *Food Consumption and Exposure Assessment to Chemicals in Food.* Geneva: WHO. [Report of joint FAO/WHO consultation that gives an overview on consumption and exposure of populations to chemicals from foods.]

FAO/WHO Codex Alimentarius Commission (1997). *Hazard Analysis and Critical Control Point (HACCP). System and Guidelines for its Application.* Annex to CAC/RCP 1-1969. Rev. 3. Rome: Food and Agriculture Organization of the UN.

HACCP (2000). Regulatory Assessment of HACCP. Special issue of *Food Control* 11 **5**, 341–422. [A series of papers dealing with principles and experiences of the implementation of the HACCP system ín different countries.]

IFT Experts on Biotechnology and Foods (2000). Labelling of rDNA Biotechnology-derived Foods. *Food Technology* **54**, 62–74. [IFT experts report on biotechnology and foods.]

Lund B.M., Baird-Parker T.C. and Gould G.W. (1999). *The Microbiological Safety and Quality of Food*. Gaithersburg: Aspen Publisher, Inc. [Food microbiology and the safety of produced foods.]

Nollet L.M.L. (1996). *Handbook of Food Analysis,* Vols. 1–2. New York: Marcel Dekker Publ. [Overview of analytical methods used in food analysis.]

Biographical Sketch

Jiří Davídek, D.Sc., is a Professor of Food Science on the Faculty of Food and Biochemical Technology, and is a member of the Department of Food Chemistry and Analysis, Institute of Chemical Technology, Prague, Czech Republic.

Professor Davídek received his M.Sc. degree from the Institute of Chemical Technology, Faculty of Food and Biochemical Technology in 1954. He obtained his Ph.D. in 1969 from the same Institute under the direction of Professor Dr. G. Janíček. After doing postdoctoral work with Dr. J. Fragner at the Research Institute of Food Industry in Prague and with Dr. A.W. Khan at the National Research Council, Division of Biosciences in Ottawa, Canada, he was appointed Associate Professor of Food Chemistry and Analysis at the Faculty of Food and Biochemical Technology, Institute of Chemical Technology, Prague, in 1960, and became a full Professor there in 1970.

Professor Jiří Davídek is a member of the Czech Chemical Society and the Chairman of the Division of Food and Agricultural Chemistry. He is a national representative in the Food Chemistry Division, Federation of European Chemical Societies (FECS) and is member of the Czech Biochemical Society, the American Institute of Food Technologists, and numerous other scientific societies. He is also a member of the editorial board of the Czech *Journal of Food Sciences*, German *European Research and Technology*, and Chinese *Biomedical and Environmental Sciences*. He has served as the head of the Department of Food Chemistry and Analysis, Dean of the Faculty of Food and Biochemical Technology in Prague, and Vice-Chairman of the Czechoslovak Academy of Agriculture. In 1972 he received the State Prize for Research, and in 1982 he was awarded both the Gold Medal from the Czechoslovak Academy of Agriculture and the Silver Medal of Professor Jaroslav Heyrovsky from the Czechoslovak Academy of Science.

Professor Davídek has published more than 330 papers and is the author of 16 books published variously in Czech, English, German, and Polish. He has also delivered more than 350 lectures at scientific conferences and symposiums. He often works as a chairman at the International meetings organized by

the Food Chemistry Division of FECS (Euro Food, Chemical Reactions in Foods, and so on). His research interest focuses on food quality, food analysis, Maillard reactions, the formation of sensory active compounds, food additives, and natural toxic compounds.