CHAPTER 7: HYGIENE AND SAFETY OF AGRO-ALIMENTARY PRODUCTS

7. HYGIENE AND SAFETY OF AGRO-ALIMENTARY PRODUCTS.

INTRODUCTION

This unit will examine the basic hygiene and safety concepts and practices for agro-alimentary products, with emphasis on quality systems and the basic principles of the HACCP system.

EXPECTED RESULTS

When you have studied this chapter

- you will know the basic principles of the HACCP system

- you will know about hazards in foodstuffs

- you will appreciate the importance of hygiene and safety for the production, standardization, packaging, distribution and consumption of (agricultural) products

- you will know the basic principles of total quality management

KEY CONCEPTS

Hygiene and Safety, hazard, risk, Quality Assurance System, HACCP Principles

7.1 INTRODUCTION TO HYGIENE

Any living organism, including humans, require food for their survival. Food consists of various liquid or solid products, foodstuffs, which in their turn are combinations of nutrients which are necessary for the basic functions of organisms.

Humans, in addition to survival, also seek a quality of life, with good health being its basic requirement. **Health** is the condition of complete physical, psychological and social wellbeing for humans. If any of the above is disrupted then a person will become ill. **Hygiene** is the branch of Medicine that is involved with the prevention of disease, methods for preserving human health at high levels and searching ways to promote health[1].

Due to the fundamental role of food in life and health, these last years, a new branch of Food Science has made its appearance, **Hygiene and Safety of Foodstuffs.** The term hygiene of foodstuffs is simply the implementation of the above definition of hygiene to foodstuffs, whereas the term **safety** means that foodstuffs contain no substances or objects that may harm humans, either in the long-term or short-term.

Risk – Hazards in Foodstuffs

Foodstuffs are directly related with the consumer's hygiene and safety. In such a relationship there is always the suspicion of a "hazard". In accordance to FAO/WHO[2] "hazard" is any biological, chemical or physical factor/capacity of a foodstuff that can result in adverse consequences to the consumer's health.

[1] Hygiene – Microbiology OEDB, 2001

[2] http://www.fao.org/docrep/W8088E/w8088e07.htm

EXAMPLE SOURCES OF INFECTION	TYPE OF INFECTION	CONSEQUENCES
Raw Materials Staff Work Surfaces Utensils, Equipment Insects – Rodents - Animals Air – Soil - Water Packaging Materials Waste Foreign bodies	BIOLOGICAL Bacteria: Salmonella, Coliform bacteria Staphylococcus, listeria Yeasts, Fungi: Moulds Viruses: Hepatitis A, Norwalk Parasites: Toxoplasmosis, Ascarides CHEMICAL Insecticides Detergents, Grease Pesticides, Oils PHYSICAL Metals, Plastic objects, Jewellery, Hair, Wood, etc.	Indisposition Headache Stomach Upset Sweating Nausea Fever Diarrhoea Vomiting Consequences on the Central Nervous System Death

Hygiene and safety management systems for foodstuffs constitute a documented method of potential hazard management in the entire chain from production, distribution to consumption. They are based on standards and principles that describe the procedures required to achieve the effective control of safe food production. The development and implementation of such a system by companies active in the foodstuffs field, contributes towards minimizing hazards during the production procedure, storage and trade of the products. The HACCP principles (Hazard Analysis and Critical Control Points) suggest the method for the development and implementation of a safety system for foodstuffs.

The European Union has made food safety a top priority. Based on directive 93/43/EEC on the hygiene of foodstuffs and more recently Regulation (EC) 178/2002 which sets the specifications for the establishment of the European Food Safety Authority, the Community seeks a new, more integrated approach, to this issue. National legislation, in harmonisation with Directive 93/43/EEC require foodstuff undertakings to apply the procedures that are necessary for monitoring the critical points during the production of foodstuffs based on the HACCP principles.

The International Organisation for Standardisation (ISO) in recognition of the need for a standard that will be the common international basis, published in September 2005 the international ISO 22000:2005 standard. The new standard includes the HACCP principles, also harmonised with the

ISO 9001:2000 standard. This standard may be implemented by all undertakings that are involved in the production, standardisation, processing and trade of foodstuffs, regardless of size.
The certification of such a system (ISO 22000:2005, HACCP) is **a strong competitive advantage** for producers of foodstuffs and a starting point for expanding their business activities and expectations.

7.2 HAZARD CATEGORIES. HYGIENE OF STANDARDISATION AND PACKAGING FACILITIES AND STAFF

7.2.1 Hazard categories.

Hazards for the hygiene and safety of agricultural products fall under three broad general categories. Each one includes hazards that may fall under smaller subcategories. In more detail:

1. **Biological hazards** are those from bacteria, viruses, parasites.

If a person consumes eggs infected with salmonella, then he may also be infected and present vomiting and diarrhoea.

2**. Chemical hazards** are those caused by harmful naturally encountered chemical substances or added chemical substances.

The incorrect use of pesticides is a hazard for chemical contamination. Thus, if a quantity of pesticide larger than prescribed is sprayed then there will be residues on the fruit in quantities greater that permitted. In this case the consumption of products may cause serious problems to the person that consumes it.

3. **Physical hazards** that come from materials that are foreign to the foodstuff. Finding a strand of hair in a packaged yogurt or a piece of metal is a physical hazard.

The most important **sources of hazards** are:

- For biological hazards:
    1. Unprocessed raw materials, mainly animal
    2. Soil
    3. Air
    4. Dust
    5. Water
    6. Dirty processing machinery
    7. Work Surfaces
    8. Production staff
    9. Insects - Rodents
- For physical hazards:
    1. Unprocessed raw materials
    2. Water
    3. Floor of facility

4. Production machinery
5. Building construction materials
6. Working staff

The above may carry foreign materials into the product, such as:

1. Glass 2. Wood 3. Rocks 4. Metals	5. Insects 6. Rodent Waste 7. Bones 8. Plastics	9. Staff waste 10. Paints 11. Grease-lubricants 12. Rust

Measures for dealing with hazards.

For each category of hazards, the suitable **measures** are **taken.**

BIOLOGICAL HAZARDS: By using processes for the destruction or inhibition of pathogen development, such as

- Pasteurisation, Boiling, Sterilisation
- Refrigeration - Freezing
- Drying
- pH reduction
- Increase of osmotic pressure – Addition of sugar
- Use of radiation – ultraviolet, gamma rays
- Antiseptic substances

Marmalades are manufactured from fruit, which as organic products are vulnerable to decay due to pathogens. To be able to conserve the marmalades for longer periods of time, and not refrigerated, we add sugar which does not allow the development of microorganisms.

CHEMICAL HAZARDS: The main measures for controlling chemical hazards, are

- The purchase of raw materials that meet specifications.
- Removal of hazards during processing.
- Implementation of G.M.P. requirements[3] (detergents and disinfectants).
- Good storage conditions (avoidance of toxin development conditions).
- Use of suitable packaging materials.
- Recording the quantities of all chemicals added to the foodstuffs

There is increased chemical risk if we do not observe the period specified between the spraying date until the harvest of the products. In this case the residues of the pesticide are high and there is risk of causing problems to consumers.

[3] http://en.wikipedia.org/wiki/Good_manufacturing_practice

PHYSICAL HAZARDS: The measures for the control of physical hazards are implemented with the use of

-Metal detectors

-Vibrating sieves

And with the implementation of

-Insect and rodent control

-Maintenance and hygiene program

-Correct practices for the management of materials

-Staff training

7.2.2 Hygiene of standardization-packaging facilities. Staff hygiene.

As we saw above, the facility materials and staff waste can cause hazards, therefore specific measures are imposed:

-Building facilities must meet modern regulations and satisfy the nature and quantity of the processed products. They must be clean and disinfected, and all the actions for organic disinsectisation-deratisation must be taken. Conditions in storage areas must be controlled based on the product's requirements. In any case however, the temperature, humidity and ventilation must be controlled. The method of storage is very important and requires appropriate archiving. It is however subject to a practice: The first in-first out practice.

An example of the first in- first out practice:

In the case of a refrigerator where tomatoes are stored, the new incoming loads must be placed behind those already in the refrigerator. The reason why the products must be placed in such a way (the old in front of the new) is that they must be made available for consumption in that order.

-The subject **of staff hygiene**, has three aspects:

- personal hygiene
- health
- hygiene of facilities

Self-evident hygiene rules of everyday life are an imperative need in packaging undertakings. Particular emphasis is placed on the thorough hand washing (after transportation outside the undertaking, bathroom visit, contact with pathogen carriers, etc). Bodily and oral hygiene are also necessary. Also, most undertakings use special uniforms. All staff hygiene regulations are recorded in hygiene manuals and the staff must be suitably trained to implement them[4].

The provisions regarding the health of employees in foodstuff undertakings are specified by health services. In any case, an employee who is ill, even from a simple flu, must declare it to

[4] Hellas, EFET, "Basic Hygiene Principles for Foodstuffs", 2001.

management and must be removed from production, perhaps at another post until recovery. It is reasonable that this important principle is overlooked most times, either due to negligence or fear and doubts.

Workers in an undertaking have personal and common-use areas, such as lockers, changing rooms, bathrooms, etc. All hygiene and cleanliness rules must be followed in these areas. In particular for bathrooms, automatic doors and faucets are frequently installed so they do not come in contact with the hands of employees (in particular those in production).

7.3 QUALITY ASSURANCE SYSTEM

Quality assurance includes all predetermined and systematic activities implemented in the framework of the effort to achieve quality and their documentation to the required extent, in order to prove that a production unit meets quality requirements and is governed by correct organization.

This definition outlines the **directions of a quality assurance system**: **organizational structure, staff,** necessary **measures** and **procedures.** Before any procedure starts (e.g. production, orders for raw materials, product transportation, etc.) the first three factors must be satisfied. The correct and constant training of the staff is required, as well as the research/recording of all elements that form the productive procedure: Management, production, quality control, economic control, sales, trade, design, supplies, facility, etc. All these elements must be harmoniously combined, without overlaps, for the creation of the desired result, i.e. the quality product. The results of these works are presented in three manuals, that must be available for every check or inspection:

- ✓ **Quality manual:** Describes the company's strategy and the elements that comprise product quality
- ✓ **Organizational procedures manual:** Presents the undertaking's organizational chart
- ✓ **Operational procedures manual**: Describes all productive procedures.

A complete flow chart for milk pasteurization must include:

Receipt of raw materials (fresh unprocessed milk)

Storage of raw materials (storage of fresh unprocessed milk in ice boxes)

Processing of raw materials (Pasteurization of milk)

Production of product (Production of pasteurized milk)

Packaging (Fresh milk packaging)

Storage in appropriate conditions (refrigerators at $< 4^{o}C$)

7.4 Total Quality Management (TQM)

TQM (Total Quality Management) as a new method for the organization of businesses, was launched in practice in 1949 by the Union of Japanese Scientists, whose direct aim was to improve productivity. It was also attempted in the USA with a delay of approximately 30 years, and specifically in the 1980s. A few years later it was first implemented in Europe.

Business management today has broken free from the traditional theories, without totally abandoning them, and has embraced the Total Quality Management (TQM) theories. It is called "Total" because it proposes the involvement of all factors participating in an undertaking, and in particular the workers, in the production procedure and "quality" because it places the focus of the undertaking's interest, not on profit as a narrow concept, but on the quality of the products and services provided, therefore respecting the customers. TQM may be characterized as a modern "management model" with the success depending on the effective achievement of the perfect combination of all production factors participating in an undertaking. As a modern and different compared to traditional concepts, philosophy, it introduces innovations that refer both to the role of management as well as the coordination and the undertaking's operations.

Through Total Quality Management, an undertaking can implement, inspect and revise the quality assurance system. **The main goals** are **customer satisfaction, public health assurance and environmental protection.**

The term **total quality** refers to a global treatment of all factors that define an undertaking's activity. These factors may be related to **human resources** such as employees, workers, salespeople, suppliers and customers, to the **market,** such as competition and marketing or to the **product's quality.**

In order for this effort to bear fruit, it must be based on three axioms:

- ✓ Commitment for constant improvement of quality and implementation of innovations.
- ✓ Scientific knowledge of the appropriate tools, techniques and methods.
- ✓ And that the entire undertaking acts like a team.

A series of actions supporting TQM arise from these axioms: correct management, economic management, the customer as the focus, constant improvement, implementation of preventive measures, etc. The purpose of these notes is to present a simple introduction to TQM and to underline that the effort to meet all quality requirements of a product of critical importance such as foodstuffs, must be based on TQM.

As a TQM example we will refer to a vertically integrated wine production undertaking (production of grapes-wine-bottling-distribution).

The sales department conveys its experience about customer preferences with regard to the quality of the end product to the wine production department, which in its turn informs the person in charge of the vineyards. The people responsible for production adapt the facts related to production to customer demands (product packaging, harvest of raw materials, proportion of grape varieties in the production of must, etc.). At the same time, grape residues from the production of wine are processed and distributed as animal feed. The raw material packaging materials are taken for recycling while liquid waste produced during grape processing is processed at the undertaking's waste treatment facility. Finally the implementation of HACCP in primary production and processing guarantees the protection of consumer health.

With this method for managing the undertaking (TQM) all goals set are achieved:

- Customer satisfaction;
- Public health assurance;
- Environmental protection.

7.5 THE HACCP SYSTEM[56]

The Hazard Analysis Critical Control Points system

is essentially a measure to prevent the occurrence of possible hazards in foodstuffs as well as their timely treatment. Using a systematic and thorough approach it inspects all stages of the production chain and delivers records that certify the product's hygiene and safety.

With regard to HACCP two critical concepts must be understood: **Hazard analysis** and **critical control points.** These are the first and second of the 7 HACCP principles. Before we look at these principles however, we will first examine the conditions for the development of the HACCP.

HACCP implementation conditions

Today **the implementation of the HACCP system in foodstuff undertakings is mandatory based on Directive 93/43/EEC.** Therefore, in order for the operator to develop this system he must take certain actions and meet **5 conditions:**

1. **Establish the HACCP team.** Each production unit must create an HACCP team, fully informed on the undertaking's matters, productive procedures, products, hazards and the HACCP of course. Depending on the size of the undertaking, the team may consist of one or more persons. In the first case it may be the director or production manager. It is better to have a person exclusive in charge of this business sector. When the HACCP team consists of more than one person, the team's coordinator is appointed and he allocates competencies. It is apparent therefore that new jobs are created in this field.

   The duty of HACCP is firstly to develop the system. This is usually realised with the help of external business consultants specialized in HACCP issues (more new jobs). Other competencies are the implementation and continuous control of HACCP, keeping records, training issues, communication with all the undertaking's departments, external or internal inspections, etc.

2. **Product description.** This condition includes anything related to the product. All company departments must supply to the HACCP teams the necessary information about the product, from its name to its last ingredient. A very important role in foodstuffs is played by characteristics, such as nutritious, organoleptic and physical/chemical capacities.

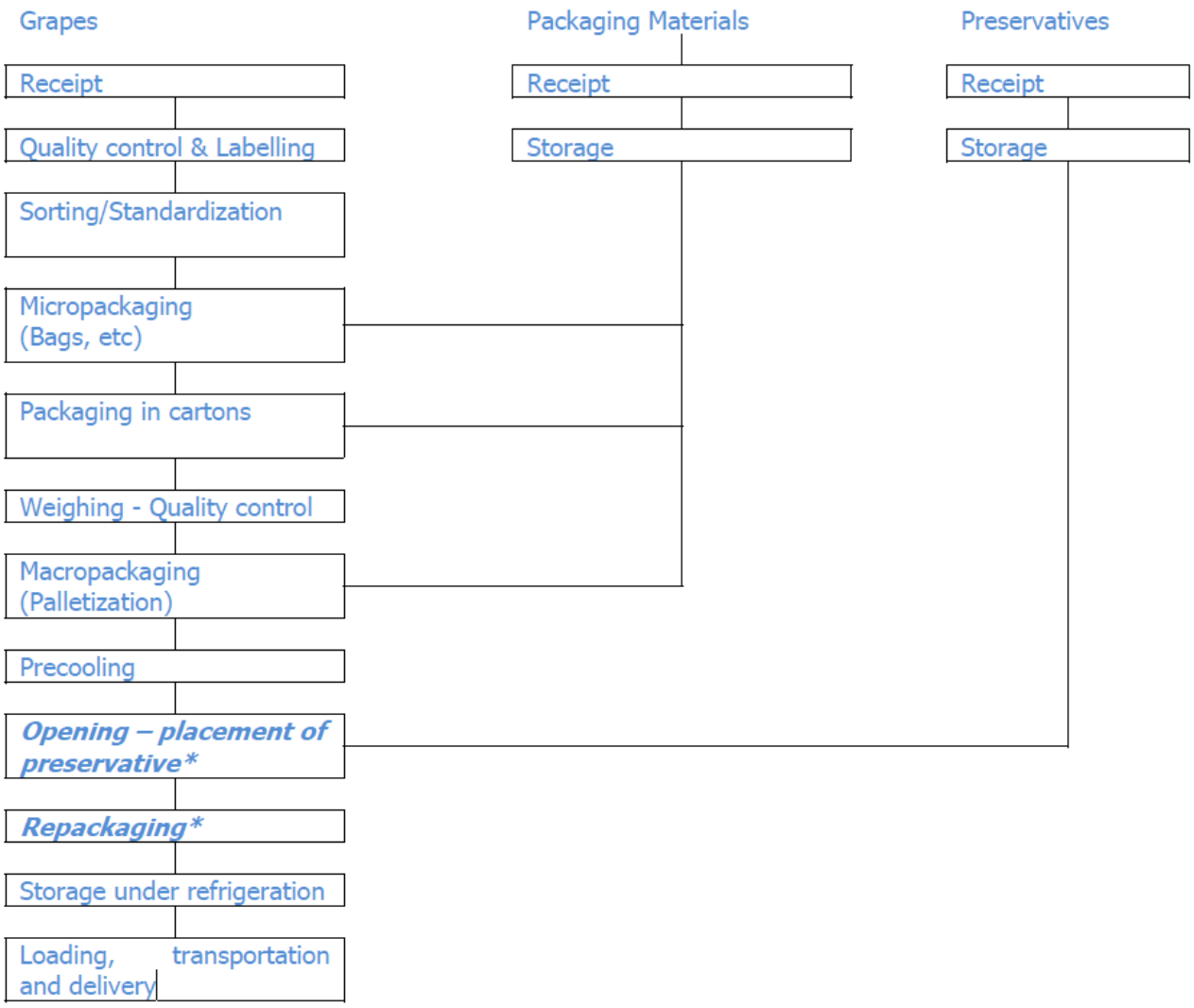
3. **Description of proposed use and the consumers of the foodstuff.** The product must be accompanied by instructions of use and maintenance. The possibility that it is directed to sensitive consumer groups, such as babies, pregnant women or the elderly, renders this condition very important.

4. **Development of production procedure flow chart.** From the above it is understood that HACCP intervenes at all stages of the production procedure. Therefore, the stages must be distinct and continuous. This is achieved with the flow chart.

A flow chart of the production procedure in the implementation of HACCP in the packaging and storage of grapes.

[5] K. Tzia, A. Tsiapouris, "HACCP", Papasotiriou, 1996.

[6] http://www.cfsan.fda.gov/~dms/fc01-a5.htm



5. **Verification of flow chart.** The HACCP group must carefully examine the flow chart of the production procedure, observe non-compliances, revise and generally verify its accuracy.

The 7 Principles of HACCP

1st Principle: Risk analysis

At this point we must stress the difference between **hazard** and **risk.** A hazard is a biological, chemical or physical factor in the foodstuff or the condition of the foodstuff that may harm the consumer. A risk is the estimated possibility and seriousness of reversible health events to populations exposed to food hazards. Therefore, HACCP seeks to reduce hazards in foodstuff, and also reduce the adverse health events related to hazards.

Risk analysis consists of three stages:

- Risk assessment, which is the quantitative assessment of information about possible hazards to the health through the exposure to various factors.
- Risk management, which is the procedure for the establishment of the necessary methods and measures of control in order to minimize risk.
- Risk communication, which is the collective procedure for the exchange of information and views on risk issues between experts, risk managers and the interested social groups.

In short, risk analysis identifies possible hazards, evaluates the possibility of their occurrence, estimates their significance and preventive measures are taken for their control.

2nd Principle: Determination of Critical Control Points (CCPs)

A critical control point is any point, stage or procedure during the processing of a foodstuff which can be controlled and lead to stopping, eliminating or reducing to an acceptable level any of the hazards that may affect the safety of the foodstuff.

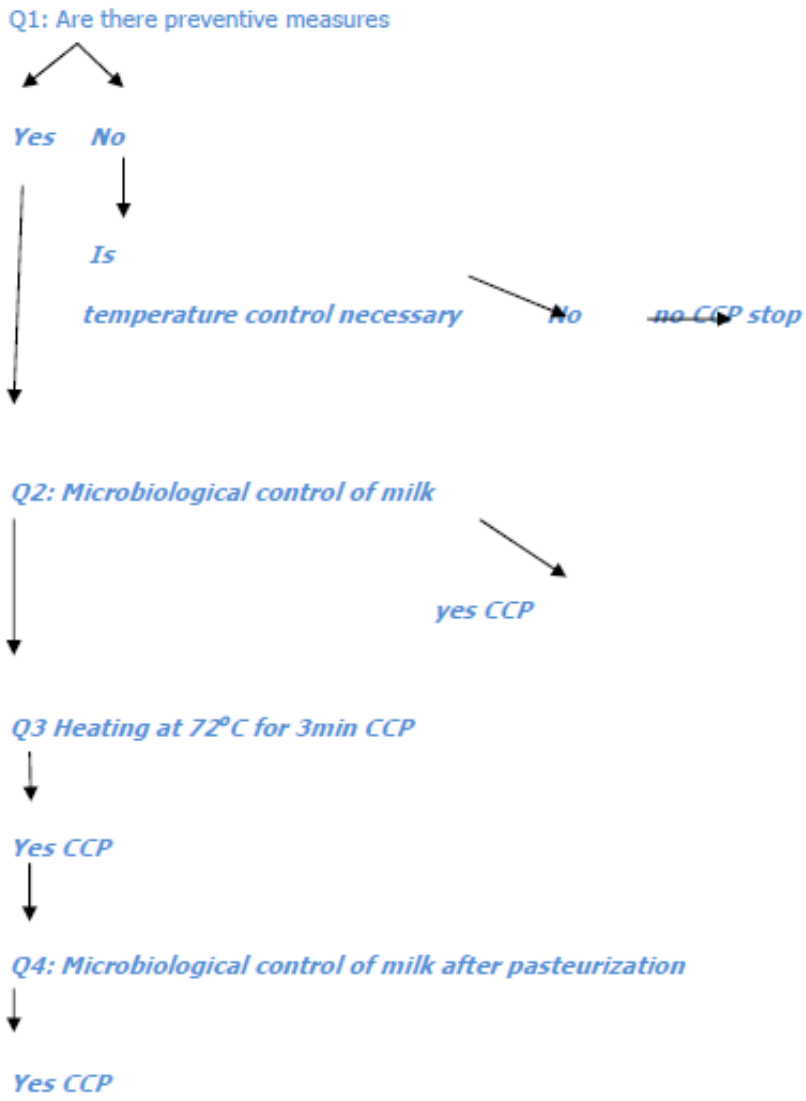
The more complex a production procedure, the greater the number of critical control points.

The determination of CCPs requires mainly knowledge and experience. A useful tool is the decision tree, which reaches a resolution through a series of questions and answers on whether each stage of the production procedure is a CCP or not[7].

To identify **critical control points** we use the decision tree, as in the following example on milk pasteurization.

DECISION TREE (Pasteurization of milk)

[7] See activity 1 at the end of the chapter. To determine the critical limits, the factors determine the CCPs must be recognized. The critical limit must not be ever violated and it must be easy to measure



3rd Principle: Determination of critical limits (CLs)

A critical limit is the maximum or minimum value against which a biological, chemical parameter must be compared in a CCP in order to eliminate, stop or restrict the appearance of a hazard at acceptable levels.

To achieve this purpose the measured parameters, the sizes, the methods of measurement, the type of hazards, etc, must be fully defined. It is based on scientific data or legislative regulations. It is also important for the HACCP team to be constantly updated on the company's new research and development (R&D).

Here is an example: In accordance with regulation 2805/73/ECC "The maximum permissible sulphur dioxide content of wine is 400mg per litre of withe wine". It is apparent that a **maximum critical limit is set** here.

• Sources of information for critical limits can be national or international legislation, experimental data, references, experienced and specialized personnel

• Factors used as critical limits:

• Temperature (e.g. the pasteurization temperature of milk is 72^{o}C for 3min)

• Time

• Humidity

• pH

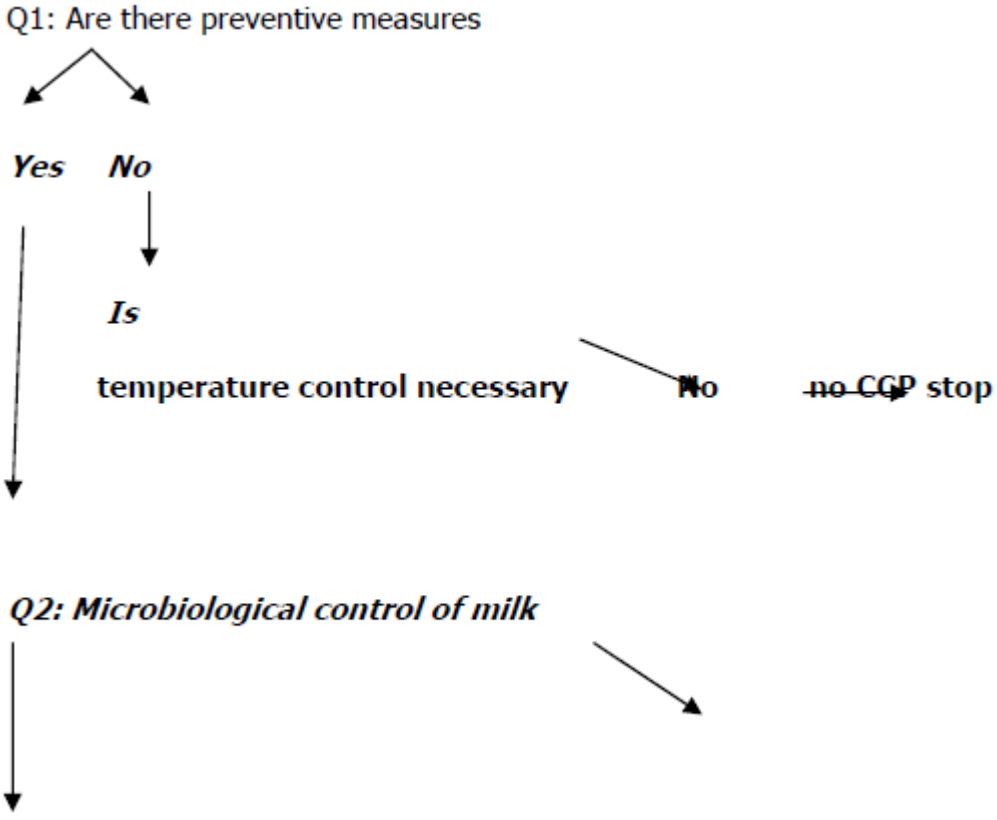
• Water activity, etc.

The categories of critical limits are those related to chemical, physical and microbiological limits.

4th Principle: Control of CCPs and CLs

This stage is very important because the necessary measures are taken after the results and assessments with regard to hazards from previous stages. The control system is set up, which can include measurements on the production line or external measurements. The system may be automated with appropriate computational packages or may require the use of specialized personnel. In any case the monitoring of each CCP must be accompanied with recordings or print-outs of the results which are then filed.

In the example we mention measurements made for the control of CCPs and CLs



yes CCP (sample)

Q3 Heating at 72°C for 3min CCP (automated recording of temperature)

↓

Yes CCP

↓

Q4: Microbiological control of milk after pasteurization (sample)

↓

Yes CCP

5th Principle: **Determination of corrective actions**

Corrective are actions that must be taken when loss of control during CCP measurements is discovered, that is, when there is deviation from a CL. This stage is important because if corrective actions are not taken the product will be destroyed.

6th Principle: System's recording and archiving procedures

In the case of recall of a product, competent authorities carry out detection procedures. This is why the HACCP control results must be correctly archived for the company's assurance. These records are also checked during inspections.

- Records for raw materials (Certifications for suitability of pasteurized milk packages, storage time before distribution, etc)
- Records related to CCPs, CL (references that support the selected CLs)
- Staff training records (training program, teaching material, trainer, etc)

7th Principle: Determination of verification procedures

Verification is realized in the form of inspections by competent authorities. Management and the HACCP team are responsible for carrying out internal inspections for the correct implementation of the HACCP system. External inspections may be carried out by the undertaking's external consultants, certification companies, state authorities and suppliers or customers.

-Sampling at milk pasteurizing line and microbiological test by independent certified laboratory.

-Inspection of CCPs, CLs records if they meet international standards, e.g. pasteurization temperature at 72°C for 3min is proposed by references, etc.

SELF EVALUATION TEST

Answer True or False to the following questions

1. Contamination may occur at all stages of the production of foodstuffs.

a) True

b) False

2. A critical control point is the determination of the point where control may be applied to eliminate a hazard or reduce it to acceptable levels

a) True

b) False

3. The temperature of areas for the refrigeration of sensitive products must range between – 2 – 0 °C

a) True

b) False

4. The quality manual describes the company's strategy and the elements that comprise product quality

a) True

b) False

Select the correct answer to the following questions

1. Physical hazards come from:

A. glass,

B. metal,

C. wood,

D. all the above

2. The number of CCPs depends on:

A. the complexity of the production process

B. the number of workers

C. the number of departments

3. What form must the TQM documentation take?

A. only hard copy

B. exclusively hard copy or electronic format (in PC)

C. only on digital media (e.g. photographs on CD, video, etc)

D. hard copy, electronic or digital format are acceptable

4. The HACCP system provides

A. Guarantee for greater safety of foodstuffs.

B. Better utilization of a company's financial resources.

C. Enhancement of customer confidence towards products and company.

D. all the above

ACTIVITIES

1. We present the production chain for citrus fruits:

The production procedure for citrus fruit is the following:

- Receipt - Inspection
- Weighing
- 1st Sorting
- Washing
- Drying
- Waxing
- 2nd Sorting
- Classification by size

1. Packaging by hand

- 3rd Sorting during placement:
- In cartons
- In wooden crates

2. Packaging by automatic machines

- 3rd Sorting before forwarding to machines
- Packaging by electronic weighing machines

- Collection of packages and placement in crates
- Palletization
- Pre-cooling at +3^{o} C

Which, in your opinion, are critical control points?

Ans. inspection during receipt, 3 sortings and time in refrigerators.

2. Try to create an HACCP system during harvest, transportation and storage of your own products with CCPs, CLs you will determine based on your own experience, everything you have read as well as the opinion of colleagues. Use the decision tree for help.

ADDITIONAL SOURCES OF INFORMATION:

http://www.haccpworks.com/haccp/Legislation.aspx

http://ec.europa.eu/food/food/biosafety/salmonella/mr06_en.pdf