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Ministry of Higher Education and Scientific Research

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Department of Biotechnology

FOOD SAFETY AND HYGIENE

Intended for: L3 Food Biotechnology Students

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Introduction and Learning Outcomes

Food is, above all, a human concern. Every day, millions of people place their trust in the foods they consume, without being able to verify for themselves their safety, composition, or production conditions. This trust, however, is not accidental; it relies entirely on the work of those who shape the food chain: agronomists, technologists, engineers, inspectors, and other professionals such as yourselves. It is precisely this challenge that this course handbook seeks to address.

Food safety is not an administrative constraint imposed on industry. It is a scientific discipline in constant evolution, built upon advances in scientific knowledge and the growing demands of consumers. From collective foodborne outbreaks to major health scandals, recent history has repeatedly demonstrated how failures in this field can have serious consequences for public health, national economies, and consumer confidence. Understanding the mechanisms that govern food quality and safety is therefore not merely an academic exercise; it is a professional responsibility.

The content of this hand book is organized into two major sections. The first, devoted to the concept of quality, encourages students to develop a critical and methodical perspective in order to answer essential questions: *What is food quality? How can it be defined, measured, and guaranteed? What are the institutional, nutritional, microbiological, and technological dimensions that constitute it, and how do they interact?* The second section introduces the fundamental principles and management systems of food quality and safety, ranging from **Good Hygiene Practices (GHP)** and the **HACCP system** to the international standards **ISO 9001** and **ISO 22000**.

By the end of this course, students will be able to:

- Define food quality and identify its essential components.
- Apply the seven principles and the twelve steps of the HACCP methodology.
- Identify and apply the seven quality management tools using food-related examples.
- Understand the requirements of ISO 9001 and ISO 22000 standards and their interrelationship.
- Implement Good Hygiene Practices (GHP) within a production environment.
- Read and interpret a quality label (AOP/PDO, IGP/PGI, Label Rouge, Halal, Organic, etc.).

CHAPTER I

WHAT'S QUALITY ?

1-Definitions and Basic Concepts

1-1-Food Hygiene

*Food hygiene is based on a set of practices to be followed during the handling of food in order to eat safely and avoid health problems. Indeed, food can be a vector of diseases since it is continuously exposed to contamination risks at the different stages of the food chain (FAO/WHO, 2005).

*According to the Hygiene Package (Article 2 of Regulation 852/2004):"Hygiene means the set of conditions and measures necessary to control hazards and ensure that a foodstuff is fit for human consumption, taking into account its intended use at all stages of the food chain."

*According to the Codex Alimentarius (CXC 1-1969, Rev. 2020): Food hygiene comprises all conditions and measures necessary to ensure the safety and wholesomeness of food at all stages of the food chain.

1-2-Food Safety

Food safety means assurance that food is acceptable for human consumption according to its intended use. An understanding of food safety is improved by defining two other concepts — **toxicity** and **hazard.**

***Toxicity** is the capacity of a substance to produce harm or injury of any kind under any conditions.

***Hazard** is the relative probability that harm or injury will result when substance is not used in a prescribed manner and quantity. Hazards can be physical, chemical and biological causing harmful / adverse effects on the health of consumers.

Physical hazard is any physical material not normally found in food, which causes illness or injury and includes wood, stones, parts of pests, hair etc. (Fig.1).

Fig. 1: Physical hazards in foods

Chemical hazards are chemicals or deleterious substances which may be intentionally or un-intentionally added to foods. This category of hazards includes pesticides, chemical residues, toxic metals, polychlorinated biphenyls, preservatives, food colours and other additives (Fig. 2).

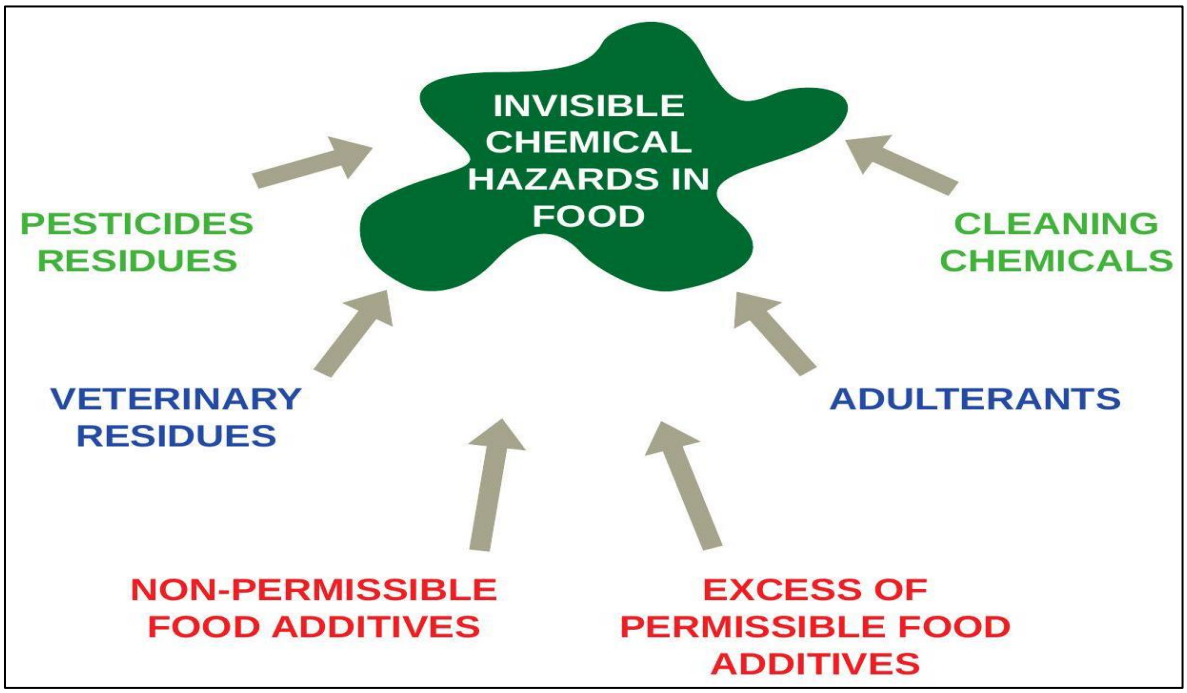

Fig. 2: Chemical hazards in foods

Biological hazards are living organisms and include microbiological organisms (Fig. 3 and 4). Those micro-organisms which are associated with food and cause diseases are termed food-borne pathogens. There are two types of food-borne diseases from microbial pathogens—infections and poisoning.

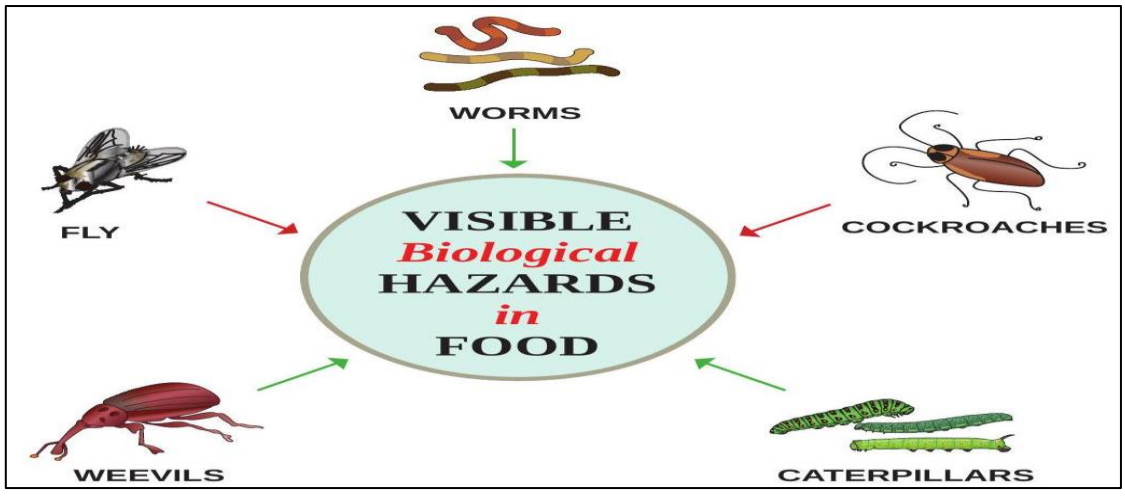

Fig. 3: Visible biological hazards in foods

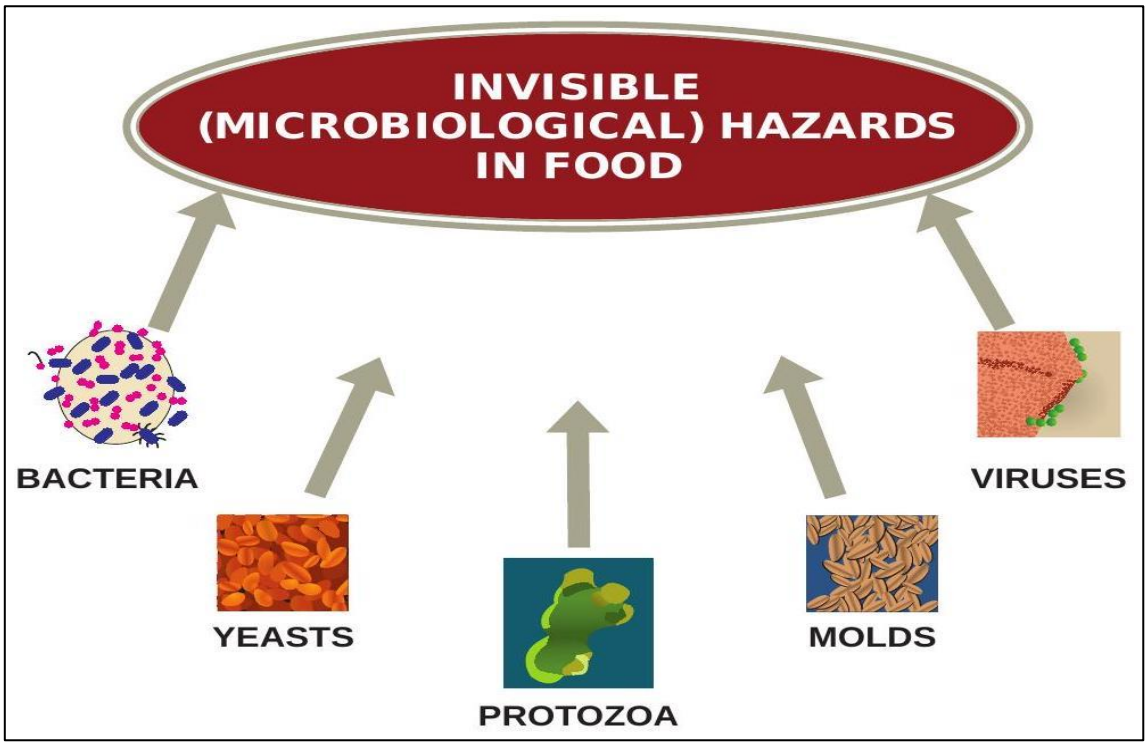

Fig. 4: Invisible/microbiological hazards in foods

Food infection / Food Poisoning results from ingestion of live pathogenic organisms which multiply in the body and cause disease. *Salmonella* is a classic example. This organism exists in the intestinal tract of animals. Raw milk and eggs are also sources.

Heat destroys *Salmonella*, however, inadequate cooking allows some organisms to survive. Often Salmonella is spread through cross-contamination. This could happen when a cook cuts raw meat/poultry on a chopping board and without cleaning uses it for another food which does not involve any cooking, such as salad. Food may become infected by Salmonella if an infected food handler does not wash hands with soap after using bathroom and before touching food. Salmonella can reproduce very quickly and double their number every 20 minutes. The symptoms of Salmonella infection include diarrhea, fever and abdominal cramps.

Food intoxication: Some bacteria produce harmful toxins which are present in food even if pathogen has been killed. Organisms produce toxins when the food has not been hot enough or cold enough. Toxins in food cannot be detected by smell, appearance or taste. Hence foods which smell and appear good are not necessarily safe. One example of such an organism is *Staphylococcus aureus*. Such organisms exist in air, dust, water. They are also present in the nasal passage, throat and on skin, hair of 50 per cent of healthy individuals. People who carry

this organism, contaminate food if they touch these places on body while food handling. Diarrhea is also one of the symptoms of this contamination (Fig.5).

Fig. 5: Infestation of foods

Among the various hazards, biological hazards are an important cause of food-borne illnesses. In spite of all the efforts in the area of food safety, microbial food-borne pathogens are still a serious concern and new pathogens continue to emerge.

Factors that are important in the emergence of pathogens include human host, animal hosts and their interactions with humans, the pathogen itself, and the environment including how food is produced, processed, handled and stored. For example, changes in host susceptibility due to malnutrition, age and other conditions can allow for the emergence of new infections in vulnerable populations. Genetic exchange or mutations in the organisms can create new strains with the potential to cause disease. Exposure to new pathogens through changes in eating habits, climate, mass production, food processing and increased globalisation of the food supply can allow pathogens to emerge in new populations or new geographic areas. Examples are Norovirus, Rotavirus, hepatitis E contributing to about 70 per cent of cases. New pathogens will continue to evolve and there is a need to develop methods to isolate them, control them and detect their presence in foods. In the context of food safety, it is important to understand the terms contamination and adulteration.

Contamination: It is the presence of harmful, or objectionable foreign substances in food such as chemicals, micro-organisms, dilutants before/during or after processing or storage. **Adulteration:** Food adulteration is the process in which the quality of food is lowered either

by the addition of inferior quality material or by extraction of valuable ingredient. It not only includes the intentional addition or substitution of the substances but biological and chemical contamination during the period of growth, storage, processing, transport and distribution of the food products. It is also responsible for lowering or degradation of the quality of food products.

Adulterants: are those substances which are used for making the food products unsafe for human consumption. (FAO, 2011; Marriott et *al*., 2018)

1-3-Definition of Quality

Quality is a complex and multidimensional concept that varies depending on context, stakeholders, and expectations. According to ISO 9000, quality is defined as: "the degree to which a set of inherent characteristics fulfills requirements."

In the food industry, quality refers to the ability of a product to satisfy consumer expectations in terms of safety, nutritional value, sensory properties, and compliance with regulations.

Quality is commonly thought of as degree of excellence. It may be considered as a set of specifications, which are to be met within given tolerances or limits. Quality Control may be defined as the maintenance of quality at levels and tolerances acceptable to the buyer while minimizing cost for the vendor.

1-3-1-Food quality attributes

Quality attributes are the characteristics that determine the overall quality and acceptability of food products. These attributes influence consumer satisfaction, food safety, nutritional value, and industrial performance. Food quality attributes are generally classified into sensory, nutritional, hygienic and microbiological, technological, and commercial attributes. The evaluation of these characteristics is essential to ensure that food products comply with regulatory standards and meet consumer expectations (FAO Food Quality and Safety).

a-Sensory Attributes

Sensory attributes are related to the characteristics perceived by human senses, such as appearance, color, flavor, odor, and texture. These attributes play a major role in consumer acceptance and food preference. The sensory quality of foods can be affected by raw materials, processing conditions, packaging, and storage. For example, inappropriate storage temperatures may alter texture and flavor, reducing product acceptability. Sensory evaluation is therefore

widely used in food industries to assess product quality and consumer satisfaction (IFST – Sensory Science Group).

The sensory attributes namely, the senses of sight, touch, taste and smell are given in Table 1

Table 1 : Classification of quality attributes

Sight	—	• Appearance • Colour • Gloss • Viscosity • Size and shape • Defects
Touch	—	• Kinesthetic (texture) • Hand or finger feel • Mouth feel
Smell and taste	—	• Flavour • Odour • Taste
Hidden	—	• Nutritive value • Adulterants • Toxicity

***Colour and gloss** Colour is an appearance property due to spectral distribution of light. Glossiness, transparency, haziness, and turbidity are properties of materials due to the differences in reflectance and transmittance of light. Physically, colour is a characteristic of light, measurable in terms of intensity and wavelength. It arises from the presence of light in greater intensities at some wavelengths than of others. Light may be reflected, transmitted, absorbed, or refracted by the object being illuminated. Spectrophotometers are used to measure colour of the products.

***Viscosity :** Viscosity or consistency is an appearance property of great importance to food products such as ketchup, creams, juices, pulp, jams, jellies, syrups, etc. The measurement may be used to indicate the consistency of the products. It may also be used as an index to the amount of ingredient in the product. Liquids flow as if they were composed of individual layers. The friction resulting from the resistance to flow between the liquid layers is called apparent viscosity. Brooke field or Ostwald viscometer is used to determine the viscosity of the product.

***Size and shape** Grading into various size and shape categories is usually one of the first steps in food processing operations. This may be accomplished by hand or by means of mechanical sorters, using screens, reels, slots, etc. Grading helps in maintaining uniformity.

• **Defects** : Defects have been defined as "imperfections, due to the absence of something necessary for perfection, or the presence of something that distracts from perfection". In grading foods for defects, tolerances may be established in terms of maximum numbers of defective units allowable.

Defects may be classified into:

1. Genetic – physiological,

2. Entomological,

3. Pathological,

4. Mechanical, and

5. Extraneous or foreign matter.

Kinesthetics of texture : Kinesthetic characteristics deal with the sense of feel. They can be classified as follows:

Finger feel:

• Firmness as encountered by the customer selecting a firm apple, measured physically by compression.

• Softness or yield quality as in selecting a peach, or plum measured physically by compression.
• Juiciness as in immature sweet corns where the thumbnail is used to test the ease and amount of juice squeezed out of a kernel.

Mouth feel:

• Chewiness, as sensed by the resistance of the product to compression and shearing action of the teeth.

• Fibrousness as sensed by the presence of an inedible residue remaining in the mouth after mastication, as well as resistance to cutting forces of the teeth.

• Grittiness, as sensed by the presence of small grit particles, such as sand, or stone cells.

• Mealiness, as sensed by the coating of starch or other material with adhesive properties, over mouth tissues.

• Stickiness, as sensed by the mouth while chewing foods with adhesive properties

• Oiliness, as sensed in the mouth, caused by oily or soapy products.

The characteristics may be determined by tenderometers, texture meters, puncture meters, succulo meters, fibro meters and pressure testers.

Flavour includes taste and odour/ aroma. Taste is a four-dimensional phenomenon, consisting of sweet, sour, salt and bitter. Sweetness can be measured by use of refractometers, sourness by pH meters, and saltiness by flame photometer or by argentometric titration. Bitterness is not estimated but compared to that of quinine sulfate. Odour/ aroma is determined by gas chromatography.

Hidden characteristics The hidden characteristics of quality are those, which the consumer cannot evaluate with his senses, and yet are of real importance to his health and economic welfare. Nutritive value is one of the hidden characteristics, which is now considered by the consumer as an important attribute. Adulterants and toxins are the other hidden characteristics. Toxins can be microbial toxins, pesticide residues or heavy metals (FAO Food Quality and Safety, 2011).

b-Nutritional Attributes

Nutritional attributes refer to the ability of a food product to provide essential nutrients required for human growth, metabolism, and health maintenance. These include macronutrients (proteins, carbohydrates, and lipids) and micronutrients (vitamins and minerals). Nutritional quality also depends on the bioavailability of nutrients and their stability during processing and storage. Food processing techniques such as heating, drying, and storage conditions may lead to nutrient losses, especially for heat-sensitive vitamins. Therefore, maintaining nutritional value is a key objective in food quality management systems (FAO/WHO, 2006).

c-Hygienic and Microbiological Attributes

Hygienic and microbiological attributes refer to the safety of food products in terms of absence or acceptable levels of harmful microorganisms and contaminants. These include bacteria, viruses, parasites, molds, and microbial toxins that may cause foodborne illnesses. Hygienic quality depends on raw material handling, production conditions, equipment sanitation, storage,

and distribution practices. To ensure food safety, Good Hygiene Practices (GHP) and Hazard Analysis Critical Control Point (HACCP) systems are applied throughout the food chain. The Codex Alimentarius standards provide internationally recognized guidelines for microbiological safety and hygiene control (Codex Alimentarius Commission, FAO/WHO, 2020).

d-Technological Attributes

Technological attributes refer to the functional and processing properties of food materials that determine their behavior during industrial transformation, preservation, and storage. These include texture, viscosity, water-holding capacity, emulsification, stability, and shelf life. Technological quality is important because it influences processing efficiency, product consistency, and final product stability. Food processing operations such as heating, freezing, drying, fermentation, and packaging can significantly modify these properties, affecting the final quality of food products (FAO, 2011).

e-Regulatory and Commercial Attributes

Regulatory and commercial attributes are key dimensions of food quality that ensure both legal compliance and market acceptance of food products. Regulatory attributes refer to the conformity of food products with national and international food laws, standards, and safety requirements. They include compliance with food composition regulations, permitted additives, contaminant limits, microbiological criteria, hygiene requirements, labeling rules, and traceability systems. These regulations are established to protect consumer health and ensure that food placed on the market is safe and correctly described. Internationally, the Codex Alimentarius provides harmonized standards for food safety, labeling, and hygiene practices that serve as a global reference for food trade and quality assurance systems (FAO/WHO Codex Alimentarius Commission, 2020).

Commercial attributes, on the other hand, relate to the market value and consumer perception of food products. They include packaging quality, labeling clarity, branding, product presentation, certification marks (such as organic or geographical indications), and price positioning. Packaging plays a dual role by protecting the product and enhancing its attractiveness to consumers, while labeling provides essential information such as ingredients, nutritional content, expiration dates, and origin. Certification and quality labels increase consumer trust and improve competitiveness in the market. In modern food systems, commercial attributes are increasingly influenced by consumer demand for transparency,

traceability, and sustainability, which directly affect purchasing behavior and product success in national and international markets (FAO, 2013).

1-4-Relationship Between Food Hygiene and Food Quality

Food hygiene is the prerequisite foundation upon which food quality is built. Without adequate hygiene, food safety cannot be guaranteed regardless of how good the quality management system is (Fig.6).

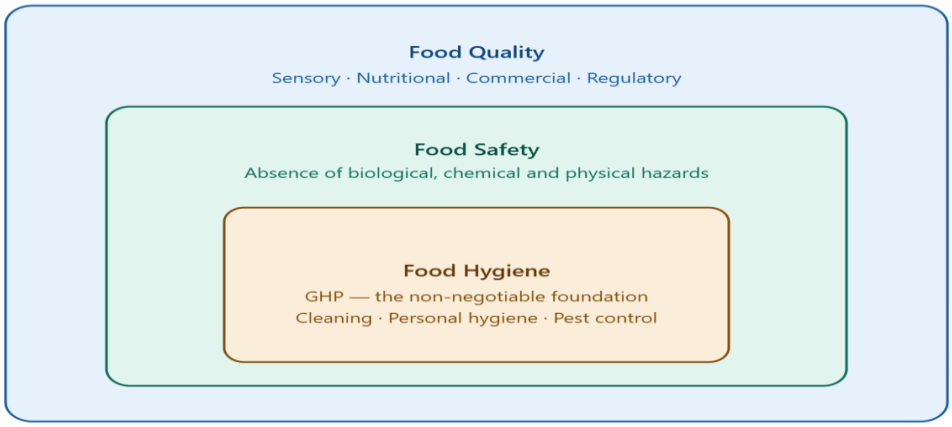

Fig. 6: Relationship between food hygiene and food quality

CHAPTER II : -COMPONENTS OF QUALITY

1-1-Definition of Quality Signs and Labels

Quality signs and labels are official, regulated, and standardized indications applied to food products in order to communicate verified information about their origin, production conditions, compliance with specifications, and quality characteristics. From a food quality management perspective, they represent a **certification system of conformity and differentiation**, ensuring that products meet defined technical, hygienic, environmental, or ethical requirements beyond basic legal food safety obligations. These systems are generally controlled by public authorities, accredited certification bodies, or recognized international organizations, and they rely on inspection, audit, and traceability mechanisms to guarantee reliability and consumer confidence. According to FAO, food quality schemes are essential tools for linking production systems with consumer expectations and market transparency, especially in globalized food chains (FAO, 2013).

Quality labels therefore serve three main functions:

1. **Information function** (informing consumers about product characteristics),
2. **Protection function** (protecting geographical names, traditions, or production systems),
3. **Market function** (adding value and improving competitiveness through differentiation).

1-2 Types of Quality Labels

a. PDO / PGI / TSG (European Quality Schemes)

The European Union quality schemes—Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Speciality Guaranteed (TSG)—are among the most structured and scientifically controlled certification systems in the world. These schemes are based on strict product specifications, official registration, and continuous control by accredited authorities.

***PDO (Protected Designation of Origin):**

This label applies to products that are produced, processed, and prepared entirely within a defined geographical area, using recognized know-how and traditional methods. The quality and characteristics of the product are essentially or exclusively due to its geographical environment, including natural and human factors (soil, climate, local expertise). Example: traditional cheeses, olive oils (Fig. 7).

Fig. 7: Example of a PDO (Protected Designation of Origin) product

***AOC (Appellation d'Origine Contrôlée – Controlled Designation of Origin):**

This is the French equivalent of the PDO. Before European harmonization, France used the AOC system to protect its products. Since 1992, with the establishment of the PDO framework, the AOC has been incorporated into the European system while retaining its national significance.

***PGI (Protected Geographical Indication):**

PGI is less restrictive than PDO. It requires that at least one stage of production, processing, or preparation occurs in the geographical area. The product has a reputation or quality linked to that region, but not necessarily all production steps. Example: regional cured meats or bakery products (Fig. 8).

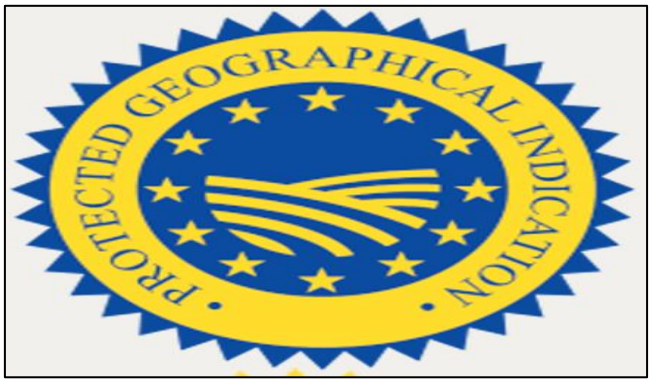

Fig. 8: Example of a PGI (Protected Geographical Indication) product

***TSG (Traditional Speciality Guaranteed):**

TSG does not depend on geographical origin but focuses on traditional composition or production methods. It highlights products with a traditional recipe or method that has been used for at least several decades. Example: traditional food preparations, Italian Mozzarella (Fig. 9).

Fig. 9: Example of a TSG (Traditional Speciality Guaranteed) product

Table 2: Comparison of PDO, PGI, and TSG European quality labels

Label	Production Area	All stages?	Example
PDO	**Specific region**	**Yes (all 3)**	**Roquefort**
PGI	**Specific region**	**Min. 1 stage**	**Parma Ham**
TSG	**Anywhere**	**No**	**Mozzarella**

b-French Quality Labels

France has developed several official quality labels recognized at both national and European levels. These labels are supervised by the Institut national de l'origine et de la qualité (INAO), which is responsible for controlling product specifications and certification procedures.

*Label Rouge

Label Rouge is an official French quality label certifying that a product has a superior level of quality compared with similar standard products available on the market. The superior quality may concern sensory characteristics, production conditions, feeding practices, or processing methods. INAO – Label Rouge Official Information

Origin: Created in 1960 under the initiative of the French Ministry of Agriculture. Its initial objective was to promote French agricultural products in response to the rise of mass production and industrial standardization. The label was inspired by traditional farming practices that prioritize quality over quantity.

The Label Rouge system is based on:

- strict product specifications,
- regular inspections,
- sensory evaluation,
- traceability controls.

It is frequently applied to:

- poultry,
- meat,
- dairy products,
- seafood,
- processed foods.

Label Rouge represents a differentiation strategy focused on high sensory and technological quality (Fig. 10).

Fig. 10: The Label Rouge logo

***Organic Farming Label (AB – Agriculture Biologique)**

The AB (Agriculture Biologique) label is the official French organic certification system. It guarantees that products are produced according to environmentally friendly agricultural methods and strict organic standards. French Ministry of Agriculture – Organic Farming

Origin: Created in 1985 by the French Ministry of Agriculture, the AB label certifies products from organic farming in France. Since 2010, it has been harmonized with the European organic logo (the EuroLeaf), ensuring compliance with the same organic standards across the European Union. Associated logos: AB Label (France) EuroLeaf (European Union) mandatory for all organic products marketed within the EU.

Organic farming prohibits or limits:

- synthetic pesticides,
- chemical fertilizers,
- genetically modified organisms (GMOs),
- excessive chemical additives.

The system promotes:

- biodiversity conservation,
- sustainable agriculture,
- soil fertility,
- animal welfare.

Regular inspections are conducted by accredited certification bodies to verify compliance with organic production standards (Fig. 11).

Fig. 11: The AB and EuroLeaf organic farming logos

c-Religious Quality Certifications

***Halal certification**

Halal certification guarantees that food products comply with Islamic dietary laws. It ensures the absence of prohibited substances such as pork and alcohol and verifies that slaughtering and processing methods follow Islamic requirements. FAO – Food and Religious Dietary Requirements

Criteria for Halal Certification :

*Ingredients: All ingredients must be lawful (Halal): alcohol, pork, and their derivatives are prohibited.

*Verification of additives and processing agents.

*Production Process : Facilities must be cleaned to prevent cross-contamination with non-Halal products.

*Compliance with hygiene standards and good manufacturing practices.

*Slaughtering Methods (for meat): Animals must be healthy.

*Slaughtering must be performed by a Muslim while reciting an invocation (Bismillah). Blood must be completely drained (Fig. 12).

Fig. 12: Example of a Halal certification logo

d-Ethical and Sustainable Labels

*Fair Trade Labels

Fair Trade labels certify that food products are produced and traded according to ethical, social, and environmental standards. These systems aim to ensure fair remuneration for producers, safe working conditions, environmental sustainability, and community development. FAO – Fair and Ethical Trade in Agriculture

Fair Trade standards promote:

- fair minimum prices,
- prohibition of child labor,
- sustainable agricultural practices,
- social equity.

These labels are particularly important for products such as coffee, cocoa, tea, and tropical fruits (Fig. 13).

Fig. 13: Example of a Fair Trade label

2-Quality Tools

2-1-Definition of Quality Tools

Quality tools are systematic methods, techniques, and analytical instruments used to identify, analyze, control, and improve quality-related problems within production and management systems. In food industries and quality management systems, these tools help organizations monitor processes, reduce variability, identify causes of non-conformities, improve decision-making, and ensure continuous improvement.

According to quality management principles, quality tools support preventive approaches rather than corrective actions by allowing early detection and control of problems during production processes (FAO, 2011).

2-1-1- Basic Quality Tools

Traditionally, a Japanese Samurai carried seven tools into battle. • After World War II the Japanese adopted 'quality' as a philosophy for economic recovery and, in line with this traditional approach, sought seven tools to accomplish the economic rejuvenation. The seven tools chosen were:

– Histograms – Cause and Effect Diagrams – Check Sheets – Pareto Diagrams – Graphs – Control Charts – Scatter Diagrams (Table 3).

Table 3: The seven basic quality tools

Tool	Tool Name	Key Question Answered
1	Cause-and-Effect Diagram (Fishbone)	Why is this problem happening?
2	Pareto Chart	Which causes should we fix first?
3	Histogram	How is our data distributed?
4	Scatter Diagram	Is there a relationship between two variables?
5	Check Sheet	How often is each problem occurring?
6	Flow Chart	What steps does our process follow?
7	Control Chart (SPC)	Is our process stable and in control?

a-Checksheet

- The function of a check sheet is to present information in an efficient, graphical format.
- For problem solving data is to be captured.
- Check−sheet is a tool to capture data as per check list.
- Check list is a tool to capture the parameter. (Fig. 14).

Sample Checksheets

Defect Type		Totals
1.Assembly	II	2
2.Print Quality	IIIIIIIIIIIII	13
3.Print Detail	IIII	4
4.Edge Flaw	IIIIIIIIIIIIIIIIIIIII	22
5.Cosmetic	IIIII	5

Customer Complaints		Totals
1.Missing Ring	II	2
2.Print Quality	IIIIIIIIIIIIIIIIIIIII	23
3.Misplace Print	IIII	4
4.Rough Edge	III	3
5.Type Error	IIIIII	6
6.Excess Flash	IIIIIIIIIIII	13
7.Late Shipment	IIIIII	6
8.Bad Count	IIII	4

Fig. 14: Example of a checksheet

b Histogram

A histogram is a graphical representation showing the distribution and frequency of data within a process. It is used to visualize variability, identify trends, and evaluate whether a process remains stable and controlled.

In food quality management, histograms are commonly applied for:

- weight variation analysis,
- microbial count distribution,
- temperature monitoring,

- moisture content evaluation.

Histograms help quality managers identify abnormal variations and determine whether corrective actions are required.

c Pareto Chart

The Pareto chart is a graphical quality tool based on the Pareto principle, which states that a small number of causes are often responsible for the majority of problems. This tool combines bars and cumulative curves to prioritize the most significant causes of defects or non-conformities. ASQ – Pareto Chart Quality Tool

In the food industry, this means: if you have 10 different types of quality defects, fixing just 2 or 3 of them (the most frequent ones) will likely eliminate 80% of your total quality problems.

This is incredibly powerful for prioritizing where to spend your time, money and effort (Fig. 15).

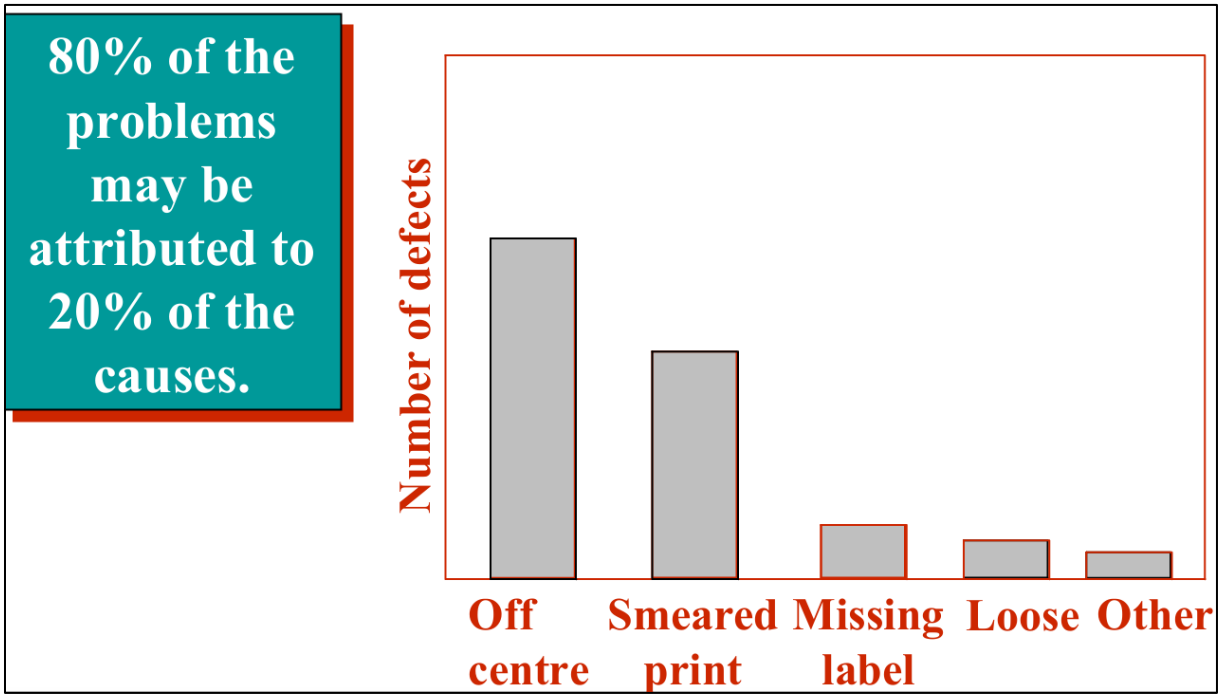

Fig. 15: Example of a Pareto chart

In food industries, Pareto analysis is used to:

- identify major contamination sources,
- prioritize customer complaints,
- analyze production defects,

- reduce critical non-conformities.

d- Cause-and-Effect Diagram (Ishikawa Diagram)

Developed by Kaoru Ishikawa (1953) Also known as: Fishbone diagrams & Ishikawa diagrams

Used to identify the potential causes of a problem. It is particularly useful in the analysis of quality defects (Ishikawa, 1986).

Use cause and effect diagram to single out variation sources within the"6M's" (Fig. 16) and (Table 4).

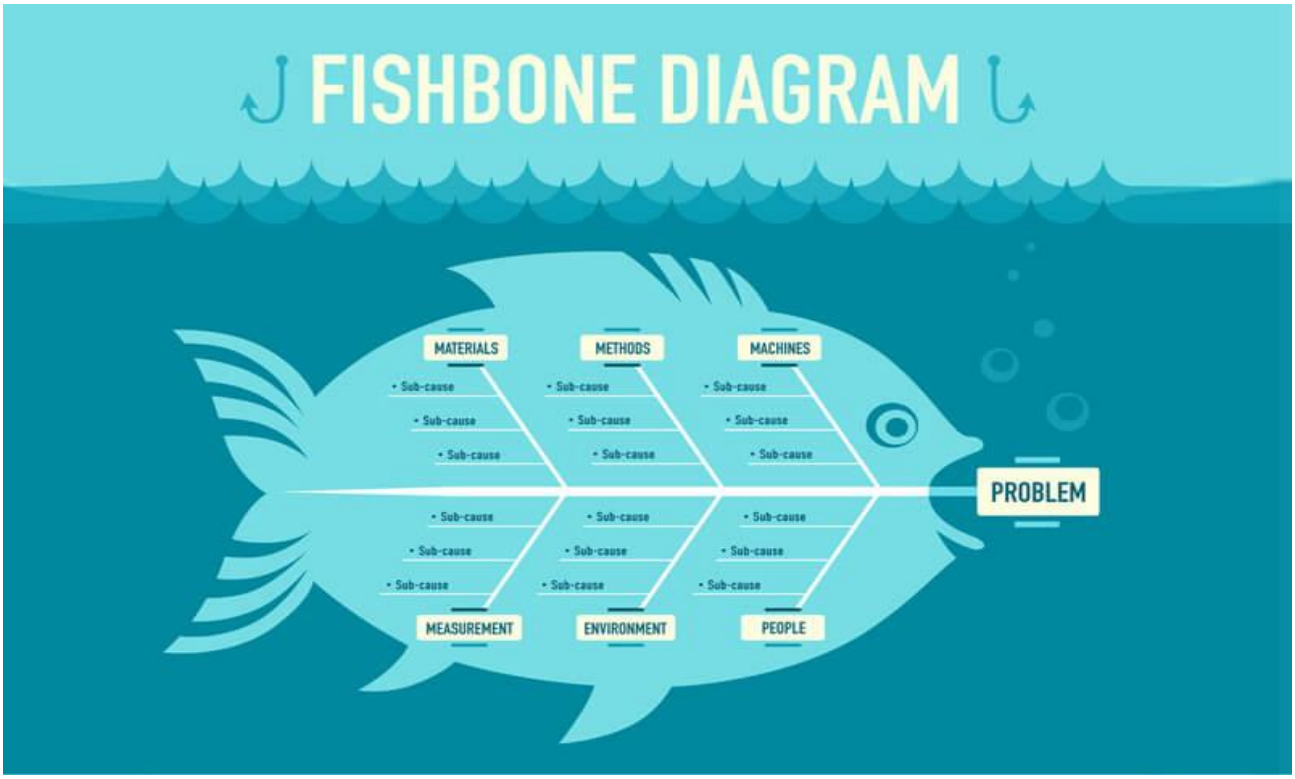

Fig. 16: Example of an Ishikawa (cause-and-effect) diagram

Table 4: 5M categories used in the Ishikawa (cause-and-effect) diagram

Category	What It Covers	Food Industry Example
Man (People)	Training, fatigue, behaviour	Operator did not wash hands; insufficient training
Machine (Equipment)	Calibration, maintenance, design	Thermostat failure in pasteuriser; worn seals

Method (Process)	Procedures, recipes, SOPs	Wrong cooling time; incorrect thawing procedure
Material (Ingredients)	Supplier quality, storage	Contaminated raw milk; poor-quality stabiliser
Measurement	Testing methods, accuracy	Uncalibrated pH meter; wrong sampling frequency
Mother Nature (Environment)	Temperature, humidity, ventilation	High ambient temperature; condensation on ceiling

How to use it (5 steps):

1. Define the problem clearly at the 'head' of the fish (be specific)
2. Draw the 6 main bones for each M category
3. Brainstorm all possible causes for each category
4. Add sub-causes and circle the most likely root causes
5. Verify root causes with data before taking action

Example : **Problem:**

Microbial contamination in yogurt production.

Possible causes (5M):

- **Manpower:** poor hand hygiene
- **Machine:** insufficient equipment cleaning
- **Method:** incorrect pasteurization temperature
- **Material:** contaminated milk
- **Environment:** poor air quality in the production area
- **Measurement:** inaccurate temperature control

e-Scatter Diagram

A scatter diagram is a graphical tool used to study the relationship between two variables and determine whether a correlation exists between them. It helps identify positive, negative, or absent relationships within production processes.

Applications in food industries include:

- relationship between temperature and microbial growth,
- moisture content and shelf life,
- pH and fermentation efficiency.

f-Flowchart

A flowchart is a visual representation of the sequence of operations within a process. It uses standardized symbols to illustrate the movement of materials, information, or activities from one stage to another. Flowcharts are essential in:

- HACCP plan development,
- food processing description,
- traceability systems,
- identification of critical control points (Table 5).

Table 5: Flowchart symbols and their meaning

Symbol	**Meaning**
Oval / rounded rectangle	Start or end of process
Rectangle	Process step or operation
Diamond	Decision point (Yes/No branch)
Arrow	Direction of flow between steps
Parallelogram	Input or output of data/materials

Example of A flowchart of yoghurt-making process (Fig. 17).

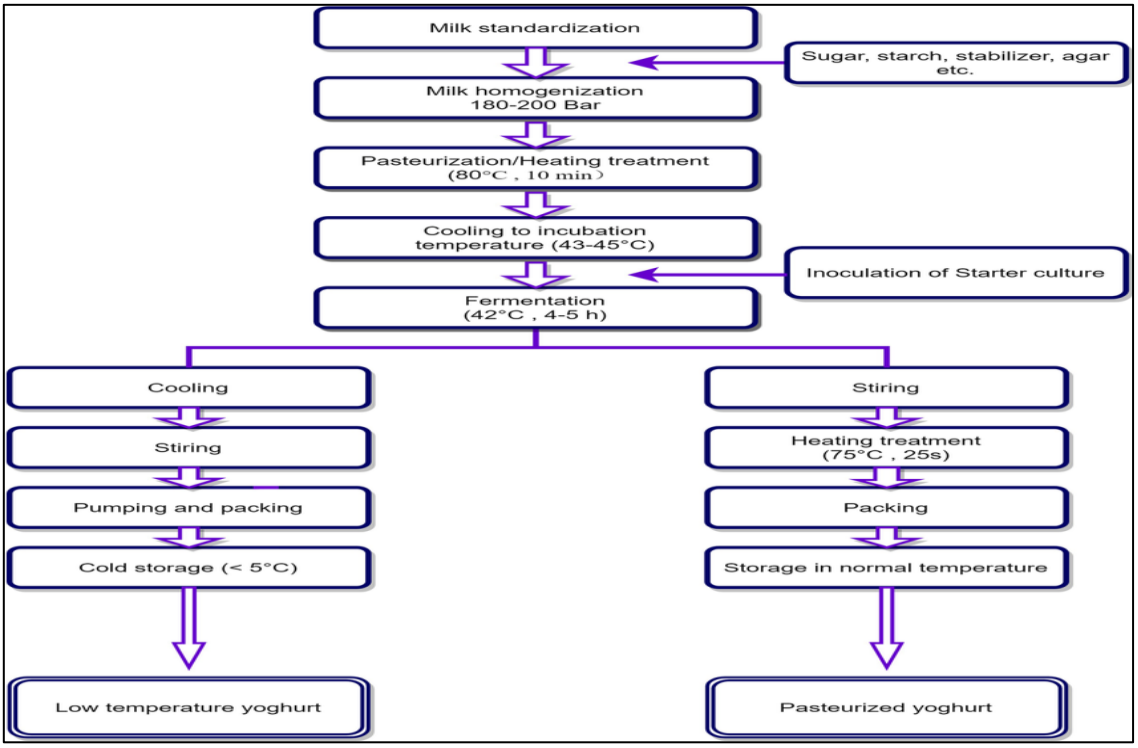

Fig. 17: Flowchart of the yoghurt-making process

g-Control Chart and Statistical Process Control (SPC)

A control chart monitors a process measurement over time and distinguishes between common cause variation (normal, inherent to the process) and special cause variation (abnormal, requires investigation).

Example : Every manufacturing process varies. No two yogurt pots will have exactly the same pH. No two biscuits will weigh exactly the same. Some variation is normal and unavoidable ; it comes from small random fluctuations in ingredients, temperature, humidity, and operator behavior. This is called **common cause variation**.

But sometimes, something unusual happens ; a thermostat fails, a new batch of ingredient arrives with different properties, or a machine part wears out. This causes an unusually large or unusual pattern of variation. This is called **special cause variation** ; and it needs to be detected and investigated immediately.

Statistical Process Control (SPC) is the use of statistical methods principally the control chart ; to monitor a process over time and distinguish between these two types of variation.

2-1-2- Continuous Improvement Tools

a PDCA Cycle

The PDCA cycle (Plan–Do–Check–Act) is a continuous improvement model widely used in quality management and food safety systems.

Plan→Do→Check→Act cycle, repeated continuously (Fig. 18).

Fig. 18: The PDCA (Plan-Do-Check-Act) cycle

b-The 5S Method

5S is a workplace organization methodology originating from Japanese manufacturing (Toyota Production System). It is based on five Japanese words all starting with the letter **"S"**, and its goal is simple: a clean, organized, standardized workplace reduces errors, contamination, and waste (Table 6) and (Fig. 19).

Table 6: The five steps of the 5S method

Step	Japanese	English
1st S	*Seiri*	**Sort**
2nd S	*Seiton*	**Set in Order**
3rd S	*Seiso*	**Shine**
4th S	*Seiketsu*	**Standardize**
5th S	*Shitsuke*	**Sustain**

Fig. 19: Overview of the 5S method

1 S: Seiri - Sort (Clean Up)

*is an ACTION to identify and eliminate all unnecessary items from your workplace.

*Keep what is useful & required

*Remove what is not useful & not required

Example : Nothing on the floor and gangways (Fig. 20).

Fig. 20: Example of Seiri (Sort) implementation

Advantages

- Tidiness & clean work place
- Pleasant Atmosphere
- Ambience conducive to thinking & improvement
- Keep all things in good condition

2 S – Seiton Set in Orde :

- is an ACTION to put every necessary item in good order
- Place for everything & Everything in its place
- Arrange necessary items in good order for use
- Set Limits for every 1 S item
- Marking / Allocation for space

Example: Pre decided Places (Fig. 21).

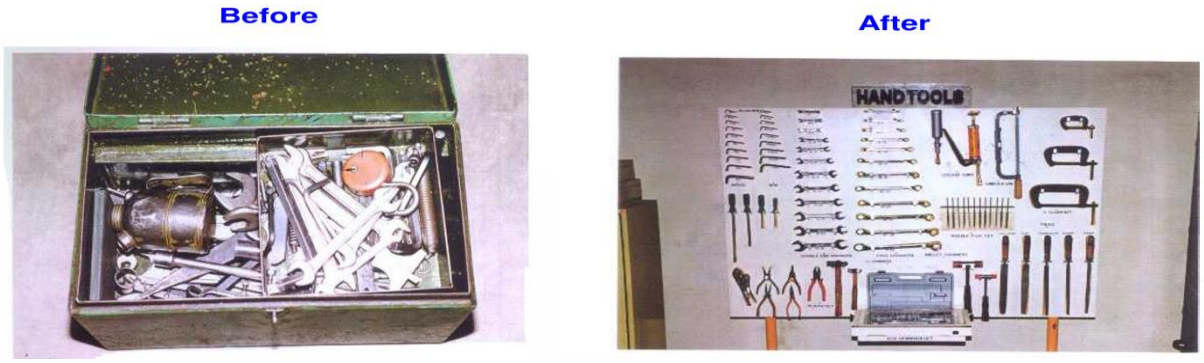

Fig. 21: Example of Seiton (Set in Order) implementation

Advantages

- More Safety. No accidents
- Excellent Product Quality, Optimum Cost, Timely delivery
- Easy to locate
- Mistake finding & immediate rectification is possible
- No futile efforts, No wastage of time
- Imbibe good habits

3S – Seiso-shine

- 3S: is an Action to clean your workplace thoroughly

- 3S is Spic & Span
- For continual improvement, keep machines & consumables clean
- It increases life of machine

Example: Laboratory Floor (Fig. 22).

Fig. 22: Example of Seiso (Shine) implementation

Advantages

- Avoid break down of machines
- Less down time of machines
- More operating efficiency
- More Productivity
- Less production cost

4 S – Seiketsu- Standardize

-Write the rules, create visual standards, post cleaning schedules and diagrams on walls so the first three S's become routine for everyone.

-4S: Purpose is to reduce time to locate the thing

Examples

- Transparent Cupboard
- Tool boxes & fixture stands at shop floor
- Different / Standard color code to Electric wire, Water line & Air lines
- Maintain file in a visible form: Use name / number / marking to each file (Fig. 23).

Fig. 23: Example of Seiketsu (Standardize) implementation

Advantages

- Reduce time to search less than 2 minutes
- Improve productivity
- Reduction in Cost
- Elimination of Non value added things

5S – Shitsuke – Sustain

-Maintain discipline through regular audits, training, and management commitment

-the hardest S, because habits are difficult to change

-If we do 1S to 4S on long term basis: 5S Culture is developed.

Advantages:

- Make your workplace more pleasant
- Makes your work more efficient
- Improves Safety
- Improves Quality of work & Products.

Why 5S Matters for Food Safety ?

Consider this scenario: in a poorly organized dairy processing room, a bottle of floor cleaning detergent (corrosive alkaline) is stored next to food-grade lubricants on an unlabeled shelf. A new operator uses the wrong product to lubricate a conveyor — chemical contamination of the product line occurs.

With proper 5S implementation:

- Chemicals are stored in a clearly labeled, dedicated chemical store (Sort + Set in Order)
- Color-coding distinguishes food-grade from non-food-grade products (Standardize)
- Visual instructions remind operators of correct product use (Standardize)
- Regular audits check that segregation is maintained (Sustain)

Hirano, H. (1995). 5 Pillars of the Visual Workplace: The Sourcebook for 5S Implementation. Productivity Press, New York. ISBN: 978-1-56327-047-1.

3- Good Hygiene Practices (GHP)

GHP are all practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain (Codex Alimentarius, 2020). They are the prerequisite foundation of HACCP — without solid GHP, HACCP cannot function.

Legal basis: Codex CXC 1-1969 (Rev. 2020); EU Regulation 852/2004; ISO/TS 22002-1.

3-1-Building and equipment

a-Location of premises : Appropriate location of building and equipment reduce the likelihood of introducing a hazard which may adversely affect the safety of food, or its suitability for consumption, at later stages of the food chain. This may help control many hazard factors that may not be in your control once the building and equipment are already set up.

Prevent contamination by locating premises away from areas that:

- Are polluted
- Contain industrial activities nearby
- Prone to flooding or pest infestation
- Make it difficult to remove waste efficiently (Fig. 24).and (Fig. 25).

Fig. 24: Example of an appropriately located food premises (1)

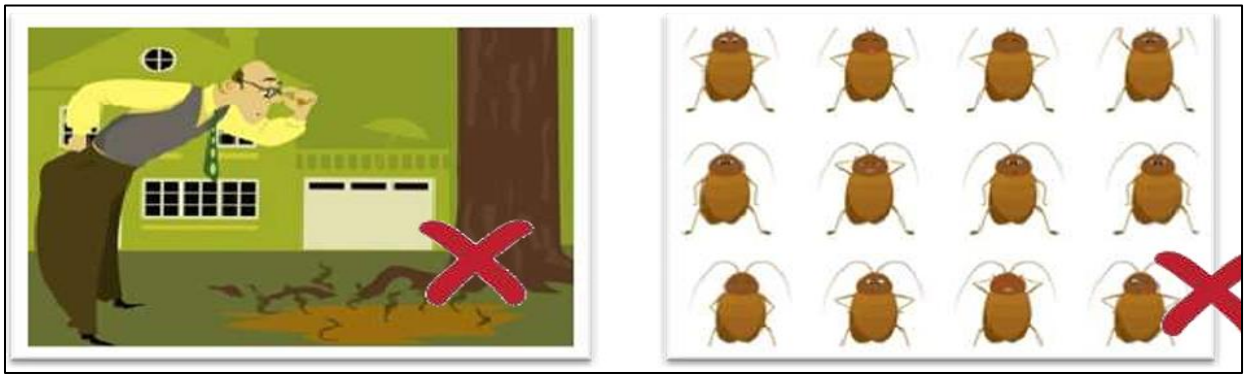

Fig. 25: Example of an appropriately located food premises (2)

b-Location of equipment : Situate / install equipment to allow

- Adequate maintenance and cleaning outside and inside
- Correct functioning (Fig. 26).

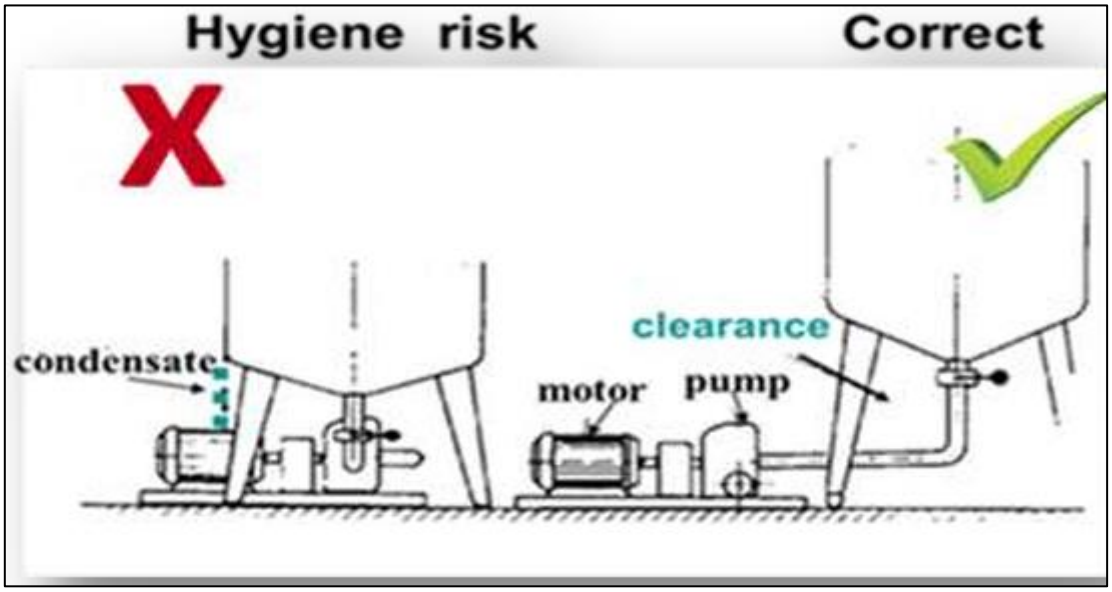

Fig. 26: Example of properly located equipment

c- Internal structures and fittings

- **Walls and floors** (Fig. 27).

Fig. 27: Example of wall/floor defects (cracks, peeling paint)

Cracks, peeling paint, toxic material on walls/floors are hazards.

Cracks on walls can harbour germs and dirt that can contaminate food. They do not allow walls/floors to be cleaned appropriately (Fig. 28).

Fig. 28: Example of smooth, impervious wall and floor surfaces

Surfaces of walls, partitions and floors should have smooth and impervious surface (Fig. 29).

Fig. 29: Fungal growth (moss) on a wall

Fungal growth (moss) on walls can release toxic spores and contaminate food (Fig. 30).

Fig. 30: Example of adequate floor drainage

Floors should allow adequate drainage and cleaning.

- **Work surface**

To avoid build-up of micro-organisms and dirt or food, working surface should be

- easy to clean, maintain ; disinfect, and made of inert (non-reactive) material (Fig. 31 and 32).

Fig. 31 & 32: Examples of easy-to-clean, inert work surfaces

- Smooth and inert work surfaces facilitate cleaning and help avoid build-up of food.

3-2- Design and layout of premises : The design and construction of food establishments play a fundamental role in ensuring food safety. From the very beginning of the planning stage, careful attention must be given to hygienic design principles, the appropriate location of the facility, and the provision of all necessary infrastructure. Taking these decisions early is critical, because once a food establishment is operational, modifying its layout or structural design becomes both costly and complicated. A well-thought-out internal layout should not only support good hygiene practices on a daily basis, but also actively prevent cross-contamination whether between different food products, between raw and processed foods, or between separate stages of the production process.

- **Layout :**

Flow of product should be linear and unidirectional i.e. from raw material to semi processed to processed.

The production line must not cross through another stage or exit close to the raw material input stage.

Food product must not be allowed to move back to the lower stage of processing for subsequent operations.

Flow of waste must be in the direction opposite to that of flow of processed food. (Fig.33 and Fig. 34).

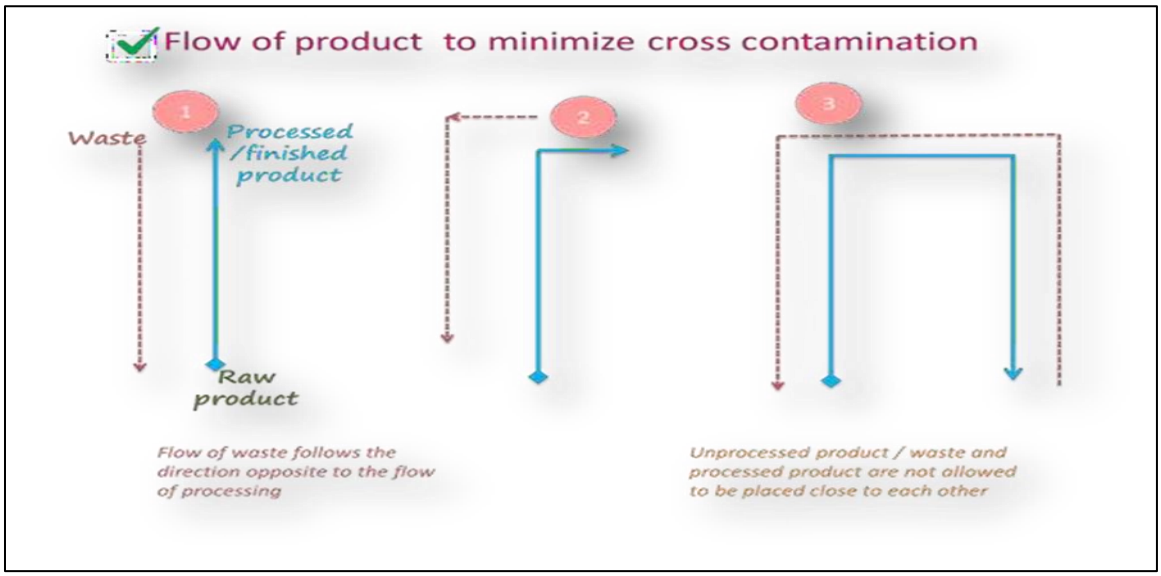

Fig. 33: Example of a unidirectional product flow layout (1)

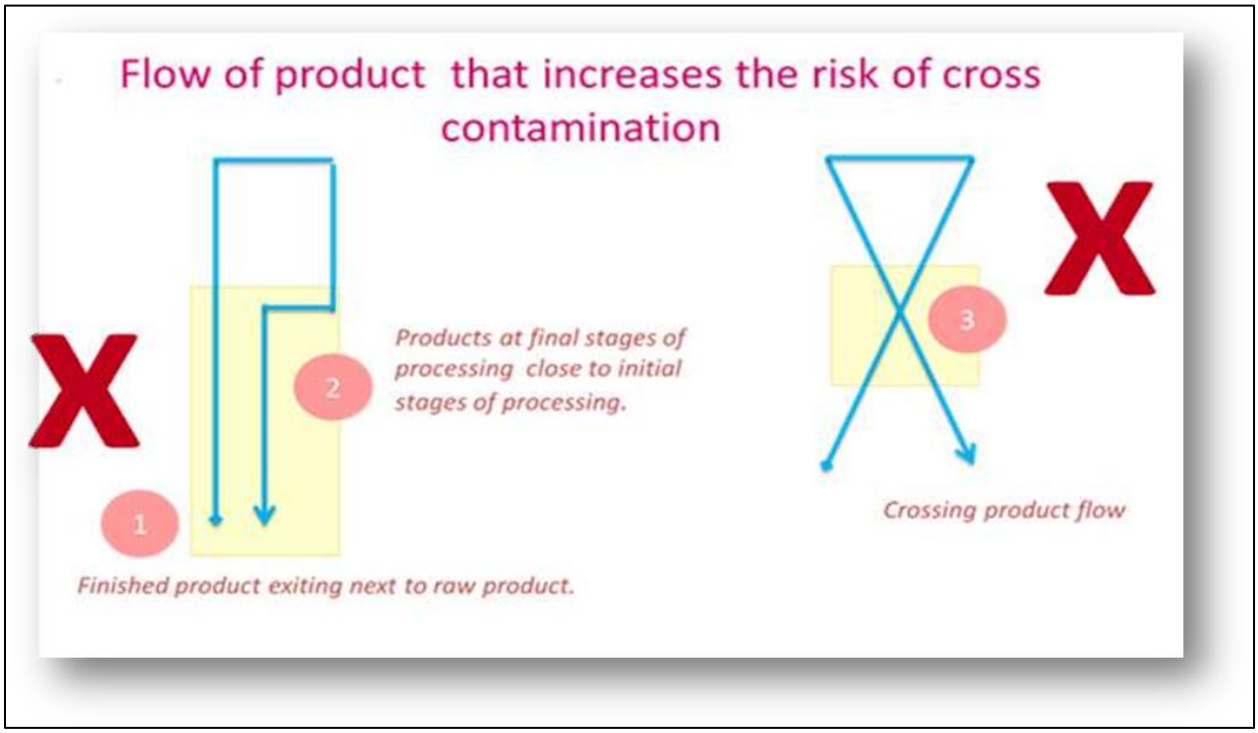

Fig. 34: Example of a unidirectional product flow layout (2)

- **Windows :** Windows should be
- easy to clean,
- constructed to minimize the build-up of dirtand where necessary,
- be fitted with removable and cleanable insect-proof screens which can prevent entry of pests into the production establishment (Fig. 35).

Fig. 35: Example of insect-proof window screens

3-3-Equipment Requirements

Equipment and containers that come into contact with food must meet the following criteria:

***Material requirements:**

- Made of clean, non-toxic materials — no toxic effect in intended use
- Smooth surfaces with no crevices where microorganisms can accumulate
- Stainless steel preferred for food-contact surfaces

***Design requirements:**

- Movable and disassemblable : for maintenance, cleaning, disinfection and monitoring
- Designed to be fully drainable when opened
- Probes and measuring devices must be detachable for calibration

***Temperature control equipment** must:

- Achieve required food temperatures as rapidly as necessary
- Allow temperatures to be monitored and controlled
- Have effective means of controlling humidity and airflow where necessary

3-4 Temperature Control and Cold Chain

Temperature control is one of the most critical GHP requirements. Most pathogenic bacteria grow rapidly between +5°C and +63°C — this is the **temperature danger zone**

***Key temperature rules:** (Table 7).

Table 7: Key temperature rules for food safety

Situation	Temperature Rule
Storage of high-risk foods	≤ +8°C (legal maximum); ≤ +4°C (best practice)
Cooling after heat treatment	From 63°C to 5°C in **maximum 4 hours**
Freezing	≤ −18°C
Hot holding	≥ +63°C

Critical temperature range to avoid	**+10°C to +60°C** — pass through rapidly

***Cooling requirements:**

- Heated product must be cooled as quickly as possible through the danger zone
- Cooling must begin as soon as internal product temperature reaches 60°C
- Cooling must achieve even temperature distribution throughout the batch

***Thawing requirements:**

- Thawing time and temperature must be strictly controlled
- After thawing, raw materials must be processed immediately or held at specified refrigeration temperature
- When using microwave: follow manufacturer's instructions to prevent uneven thawing
- Never thaw at room temperature

***Refrigeration facilities** must have:

- Devices to monitor and record temperature continuously
- A reliable alarm system (audible or visual) to signal loss of temperature control
- Monitoring devices placed to record the maximum temperature in the refrigerated area as accurately as possible

2-3.5 Prevention of Cross-Contamination

Cross-contamination is the transfer of hazardous microorganisms or substances from one food to another — directly or via surfaces, equipment, or people.

***Key prevention measures:**

- Always separate cooked/ready-to-eat foods from raw ingredients, never allow contact
- Restrict access to the food processing area ; only authorised staff and visitors
- All visitors entering food processing areas must wear overalls, gloves, and hairnets
- Prevent entry of dust, fumes, smoke and insects through physical barriers (doors, screens, airlocks) (Fig. 36 and 37).

Fig. 36 & 37: Examples of physical barriers preventing cross-contamination

3.6 Personal Hygiene of Food Handlers

People who do not maintain appropriate personal cleanliness, or who have certain illnesses, can contaminate food and transmit illness to consumers.

***Health status : conditions requiring exclusion from food handling** (Table 8).

Table 8: Health conditions requiring exclusion from food handling

Condition	Action
Diarrhoea or vomiting	Excluded — must not handle food
Jaundice	Excluded — possible hepatitis A
Fever or sore throat with fever	Excluded
Infected skin lesions (boils, cuts)	Excluded or covered with waterproof dressing
Discharge from ear, eye or nose	Excluded

***Handwashing :when it is mandatory:**

- At the start of food handling activities
- Immediately after using the toilet
- After handling raw food or contaminated material
- After smoking

***Protective clothing requirements:**

- Suitable protective coat or uniform
- Head covering (hairnet or cap — covers all hair)
- Footwear dedicated to the food area

- Gloves: must be fresh and clean; change as often as you wash hands; contaminated gloves are a food hazard

***Prohibited behaviours in food handling areas:**

- Smoking, spitting, chewing gum or eating
- Sneezing or coughing over unprotected food
- Wearing jewellery, watches, pins or personal effects that could fall into food or harbour bacteria

3-7- Cleaning and Maintenance

***Repair and maintenance:**

- Equipment and premises must be kept in appropriate state of repair
- Dirty or poorly maintained equipment promotes food hazards, pests and contamination
- Carry out repairs early : do not wait for breakdown
- Grease and oil from machinery can drip into food if equipment is not maintained

***Cleaning method**

- **Cleaning** should remove food residues and dirt which may be a source of contamination.
- **Disinfection** reduces microorganisms to safe levels : may be necessary after cleaning

***Choice of detergent** (table 9).

Table 9: Example of appropriate detergent selection

Food residue	*Solubility in water*	*Ease of removal*	*Detergent*
protein	insoluble	difficult	Chlorinated alkaline
fats/oils	insoluble	difficult	Alkaline
carbohydrates	soluble	easy	Alkaline
minerals / salts	variable insolubility	variable	acid

***Cleaning chemicals must be:**

- Handled and used according to manufacturer's instructions

- Stored separately from food
- Clearly identified to avoid any risk of contaminating food
- Food compatible (safe for food contact surfaces)

***Cleaning and disinfection programme must:**

- Ensure all parts of the establishment are appropriately cleaned
- Include cleaning of cleaning equipment itself
- Be continually and effectively monitored for suitability and effectiveness

3-8- Transportation

Food can become contaminated during transport even when all hygiene measures have been correctly applied earlier in the food chain. Transportation is therefore a critical GHP requirement that must not be overlooked.

***Requirements for transport vehicles and containers:** (Table 10).

Table 10: Requirements for transport vehicles and containers

Requirement	Detail
No contamination	Vehicle and containers must not contaminate foods or their packaging
Cleanable	Must be effectively cleaned and disinfected between loads : especially between different foods and between food and non-food items
Separation	Must permit effective separation of different foods, or foods from non-food items
Protection	Must protect food from dust, fumes, spilled liquids, and other sources of contamination
Temperature control	Must maintain required temperature, humidity and atmosphere to prevent microbial growth and deterioration
Monitoring	Must allow temperature and humidity to be checked during transport where needed

3-9-Product Information and Labelling

Insufficient product information, or inadequate consumer knowledge of food hygiene, can lead to products being mishandled at later stages in the food chain : resulting in illness or products becoming unsuitable for consumption, even when adequate hygiene controls were applied during production.

Every food product must carry sufficient information to enable:

- The next person in the food chain (retailer, caterer, consumer) to handle, display, store, prepare and use the product safely and correctly
- Consumers to make informed choices about ingredients, contents, allergens and additives

***Mandatory labelling elements:** (Table 11).

Table 11: Mandatory food product labelling elements

Label Element	Purpose
Ingredient list	Informs consumer of all components including allergens (must be highlighted)
"Best before" date	Indicates when the product may begin to deteriorate in quality
"Use by" date	Indicates the safety deadline — product must not be consumed after this date
Storage instructions	Prevent contamination and uncontrolled microbial growth (e.g. "Keep refrigerated at ≤4°C")
Preparation instructions	Ensure correct cooking temperature is reached to eliminate pathogens
Lot/batch number	Essential for product recall and effective stock rotation — identifies producer and production lot

3-10- Training

Inadequate hygiene training and supervision of all people involved in food-related activities pose a direct threat to food safety. Training is not optional : it is a fundamental GHP requirement.

***Who must be trained**: All personnel who come directly or indirectly into contact with food must be trained and/or instructed in food hygiene to a level appropriate to the operations they perform.

***What training must cover:**

- Each person's role and responsibility in protecting food from contamination or deterioration
- The knowledge and skills necessary to handle food hygienically
- Safe handling of cleaning chemicals and other potentially hazardous substances for those who use them

(FAO/WHO, 2005; Codex Alimentarius Commission, FAO/WHO, 2020)


GHP
GMP
QMS
HACCP
ISO 9001
ISO 22000

4-HACCP

4-1 What is HACCP?

The concept of Hazard Analysis and Critical Control Points (HACCP) is a preventive system to guarantee the safety of food for the consumer. It focuses on the prevention of physical, chemical and biological hazards rather than on carrying out inspection of the finished products.

The HACCP approach was developed in 1959, when NASA commissioned the Pillsbury Company to produce food for astronauts. The food had to be absolutely safe to exclude any risk to the health of the astronauts, who would be cut off from medical care for weeks. The company applied the FMEA method (Failure Mode and Effect Analysis) to the production of food. Later on this approach was further developed, and was first released in 1971. Since 1993 the application of HACCP has been recommended by the Codex Alimentarius published by FAO (Food and Agriculture Organization of the United Nations).

The HACCP concept requires a company:

- To analyse all risks within its control related to the safety of its products;
- To identify critical points for control of the quality of food;
- To define critical limits for relevant parameters at the critical points;
- To establish procedures for continuous control of food safety;
- To define corrective measures for deviations;
- To regularly check whether this system is appropriate and effective;
- To document all measures taken. (Fig. 38).

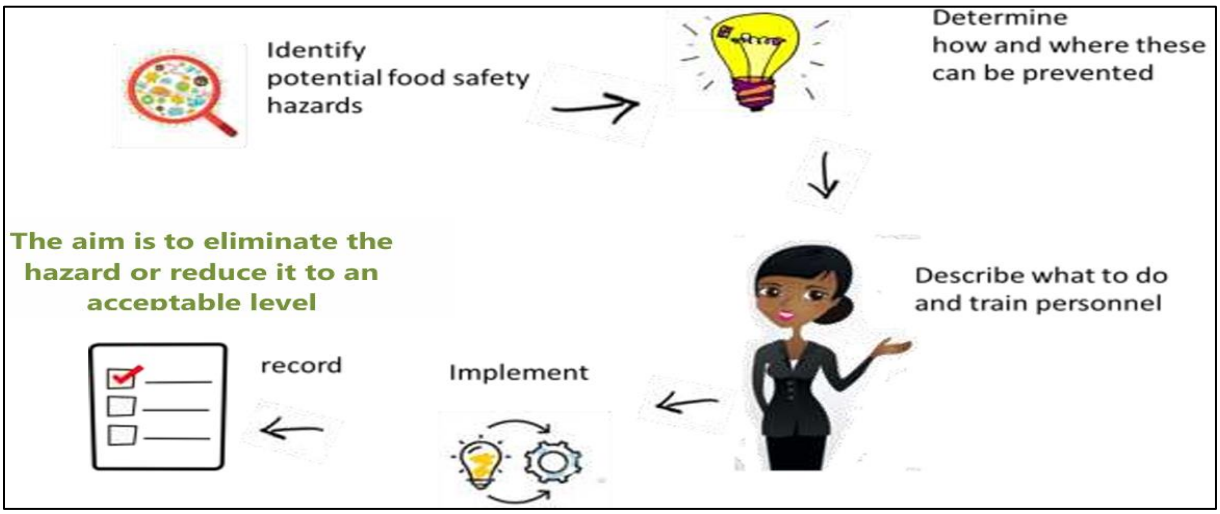

Fig. 38: Overview of the HACCP concept

4-2-HACCP Key terms

Hazard: A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Agent: Bacteria, Viruses, Moulds, Parasites, Toxins, Chemicals, Foreign material Adverse health effects: Examples:

- Acute illness (choking, vomiting, abdominal cramps, diarrhoea, nausea, fever)
- Chronic illness (chronic infections, organ damage, cancer)
- Death Control measures: Actions and activities that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Acceptable level: Not all levels of all agents are harmful to all individuals under all conditions. Agents (contaminants) are acceptable as long as their levels remain below a certain maximum. This level is called the Acceptable Level.

- If an agent is present in a food in high, unacceptable, level, its reduction to an acceptable level should be assured.
- If an agent is present in a food at a low, acceptable, level, its increase to unacceptable level should be prevented. (Fig. 39).

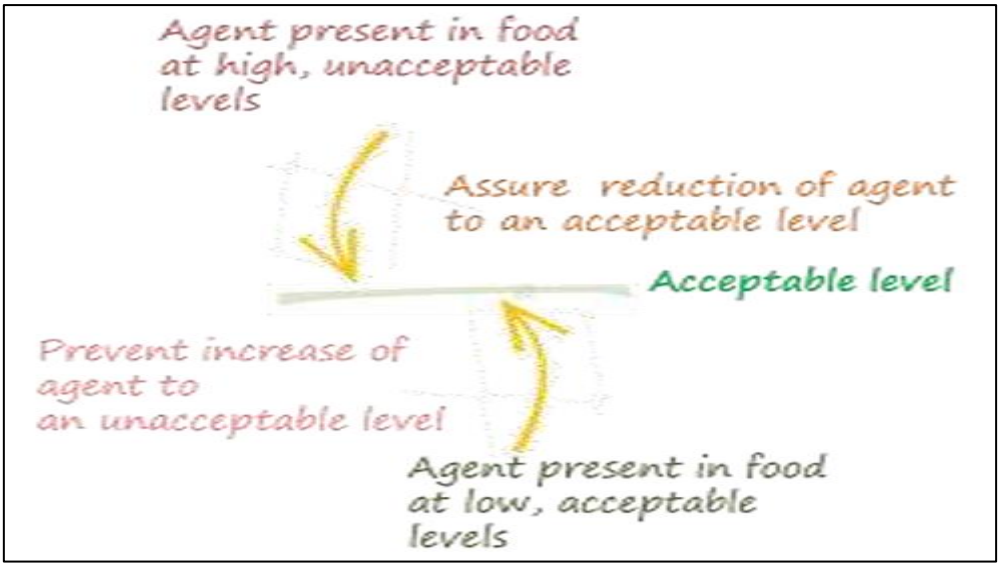

Fig. 39: Illustration of the acceptable level concept

4-3- The 7 principles of HACCP

HACCP is based on seven established principles, as defined by FAO:

Principle 1: Conduct a hazard analysis : The Codex defines a hazard as "A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect". The hazard analysis identifies which hazards need to be controlled to prevent the contamination of food.

Principle 2: Identify critical control points : According to the Codex a critical control point (CCP) is a point, step, or procedure in a food process at which control should be applied so that a food safety hazard can be prevented, eliminated, or reduced to an acceptable level.

Principle 3: Establish critical limits for each critical control point : A critical limit represents the boundaries that are used to ensure that a process step produces safe products. Critical limits are set for factors such as temperature, exposure time, physical product dimensions, water quality, moisture level, etc.

Principle 4: Establish requirements for monitoring critical control points : Monitoring activities are necessary to ensure that the process is under control at each critical control point. Therefore, it is important to specify fully how, when and by whom monitoring is to be performed.

Principle 5: Establish corrective actions : The Codex defines corrective action as "any action to be taken when the results of monitoring at the CCP indicate a loss of control". Loss of control is considered as a deviation from a critical limit for a CCP. All deviations must be controlled by taking action(s) to control the non-compliant product and to correct the cause of non-compliance.

Principle 6: Establish verification procedures : The Codex guidelines define verification as "the application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with the HACCP plan". Verification and auditing methods, procedures and tests, can be used to determine if the HACCP system is functioning correctly.

Principle 7: Establish documentation and record keeping : A record shows the process history, the monitoring, the deviations and the corrective actions (including disposition of product) that occurred at the identified CCP. It is imperative that the manufacturer maintain

complete, current, properly filed and accurate records. The following figure shows the seven principles of HACCP. (Fig. 40).

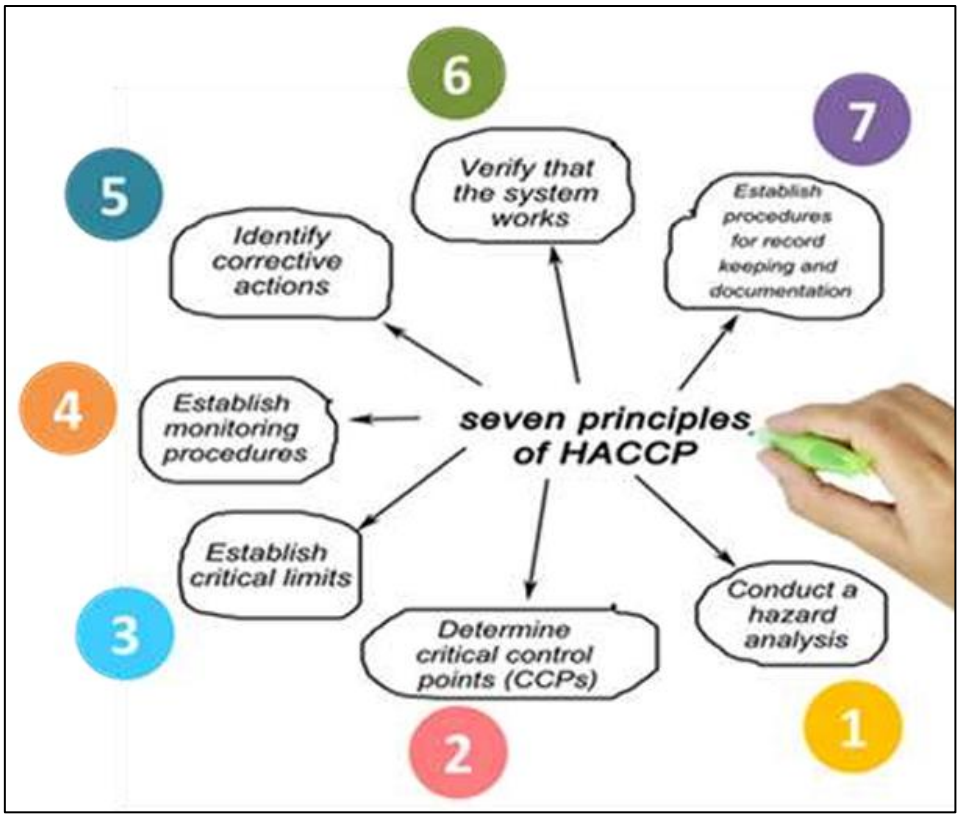

Fig. 40: The seven principles of HACCP

4-4- The HACCP Plan

The HACCP plan is the documentation produced that shows how significant hazards will be controlled. It indicates what needs to be done, when and where, and by whom. The HACCP plan is a formal document, holding all details of areas critical to food safety management for a product or process. It is the result of a HACCP study, and is specific to a production site and the product. It consists of the following.

1. Core plan:

- Valid process flow diagram
- Documented CCP management details (captured in a HACCP control chart or CCP management table)

An example of a HACCP control chart is as follows (Fig. 41).

1 CCP	2 Hazard to control	3 Critical limits	Monitoring				8 Corrective action	9 Verification
			4 What?	5 How?	6 Frequency	7 Who?		
1.1 Incoming raw material	Aflatoxin	<10 mg/kg	Flour	Inspect Certificate on analysis	Every batch	Incoming goods clearance staff	Reject batch	Samples tested regularly and matched

Fig. 41: Example of a HACCP control chart

2-Support documentation: This comprises the preparatory documentat that has been used in deelopoing the HACCP plan as well as details of the verification requirements, including the following.

- HACCP team details
- Product/process description (including terms of reference, consumer targt group and intended use of the product)
- Hazard analysis details
- CCP identification – details of approach and justification
- HACCP verification plan
- HACCP audit and review data
- Documenting the HACCP study and HACCP plan development

4-5-Implementing the HACCP Plan

The steps involved in developing and implementing a HACCP plan are as follows:

a. Assemble HACCP team (Pre-Step 1) Appoint a multidisciplinary team with a HACCP coordinator. The team may comprise, for example, a food technologist, microbiologist and the supervisors of the following sectors: quality assurance, engineering, purchasing, production,

maintenance. If necessary, external help can also be availed of. At this stage, the scope (terms of reference) of the HACCP plan should be defined, i.e. the product or process lines for which the HACCP plan should be prepared. Then, the nature of the hazards (biological, chemical or physical or their combination) to be studied by the team should be determined.

b. Describe the product (Pre-Step 2) Describe the product e.g. its

• composition (ingredients), • structure (liquid, powder or solid), • processing condition (heat treatment, freezing, brining), • packaging (bottled, packed or in bags), • storage (ambient temperature, refrigeration, freezing), • distribution (transport condition, e.g. ambient temperature, refrigeration), • shelf life.

c. Identify intended use (Pre-Step 3) Describe the expected use of the product and by whom: • by the end user (restaurant, food processor, retailer, consumer) or • consumer (adult , child, elderly, patients in hospitals, pregnant women) • whether the product should be consumed as is, drained, cooked (fried, baked, steamed).

d. Construct flow diagram (Pre-Step 4) Prepare a detailed process flow diagram or diagrams showing each step in the operation from receipt of raw materials up to defined end use (receipt, storage, processing, storage, transport, end use). The flow charts should also indicate time and temperature requirements, product recycle or rework loops, equipment layout, personnel routes, water and water flow, waste flow. (Fig. 42).

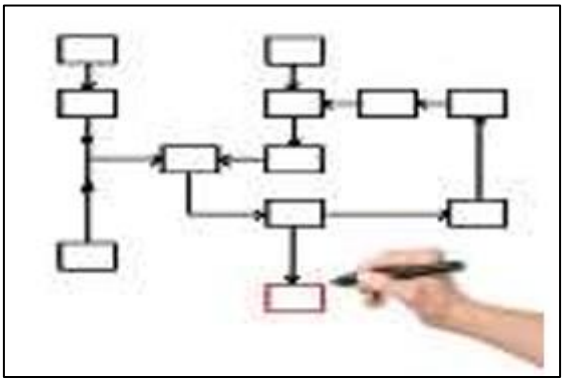

Fig. 42: Example of a process flow diagram

e. On-site conformation of flow diagram (Pre-Step 5) Observe actual operations during the normal working day, nightshift, weekend and confirm or amend the flow diagram to reflect the actual steps.

f. List all potential hazards associated with each step, conduct a hazard analysis, and consider anymeasure to control hazards (Codex HACCP: Principle 1)

- List all potential hazards (identified in the scope) at each step of the process.

- Conduct a risk analysis of each hazard (probability of occurrence and its potential severity) to identify which hazards are of such a nature that their elimination or reduction to acceptable level is essential to the production of safe food.

- Describe the preventive measures (control measures) for each identified hazard (e.g. supplier control procedure, chilling, heating, screening, metal detection, personnel hygiene such as hand washing, headgear use, cleaning, maintenance).

g. Determine critical control points (CCP) (Principle 2) Apply the decision tree (as prescribed in the Codex General Principles of Food Hygiene) at each step (for each hazard) and identify the steps where control is critical for assuring the safety of food. These steps are called CCP.

h. Establish critical limits for each CCP (Principle 3) : Specify the critical limit (control parameter that should be achieved to ensure that the product is safe, e.g. measurements of temperature, time, moisture level, pH, water activity (Aw), available chlorine and observation of sensory parameters such as visual appearance and texture, for each CCP. Critical limits are decided on the basis of a legal requirement, national or international standards or scientific data (Fig. 43).

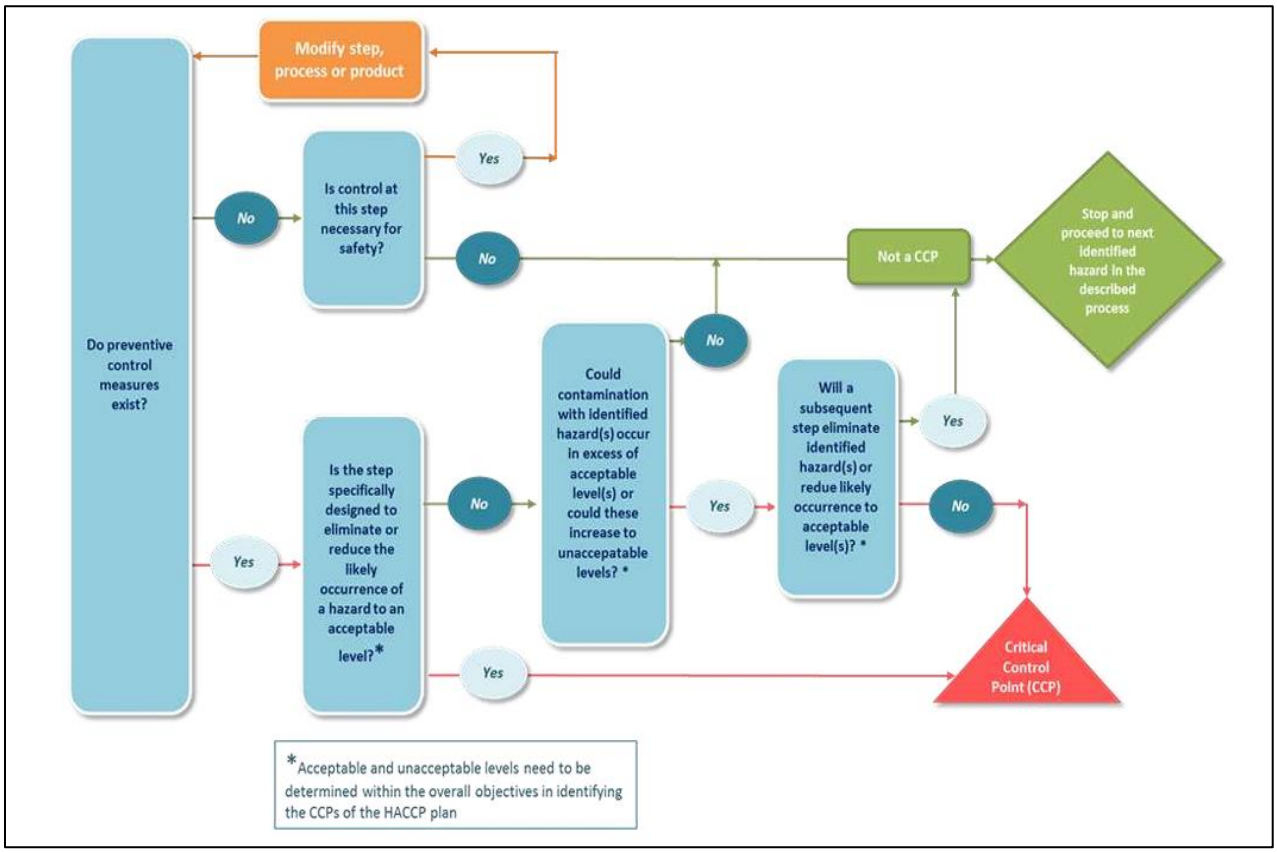

Fig. 43: HACCP decision tree to decide CCP

i. Establish a monitoring system for each CCP (Principle 4)

- Select an appropriate method for monitoring observation, testing, measurement). (e.g. inspection,

- Decide the frequency of monitoring, assign responsibility for monitoring activities and keep a record of monitoring results.

j. Establish corrective actions (Principle 5)

- Specify the action(s) to be taken to bring the process back to a state of being under control when the results monitored indicate a trend towards loss of control.

- Specify the disposition action to be taken on the product that has been produced when the CCP was out of control.

- Define the responsibility for corrective action and disposition action.

- Maintain a record of the action(s) taken.

k. Establish verification procedures (Principle 6)

With a view to checking if the HACCP system is working satisfactorily, draw up the procedure for verification activity and designate responsibilities for it. Verification activities include review of the HACCP system and its records, internal and external auditing, random sampling, product testing, analysis of swabs.

l. Establish documentation and record keeping (Principle 7) Document and keep records efficiently, as required by the HACCP system. For example, hazard analysis, identified CCPs and their limits (including revisions, if any) should be documented. Examples of records are CCP monitoring records, records of deviation found and corrective action taken on them, verification records.

5- ISO Standards

5.1 Introduction to ISO

ISO (International Organization for Standardization) was founded in 1947 in Geneva, Switzerland. is a worldwide, non-governmental federation of national standards bodies (ISO member bodies). The mission of ISO is to promote the development of standardisation and related activities in the world with a view to facilitate the international exchange of goods and services, and to develop cooperation in the spheres of intellectual, scientific, technological and economic activity. The work done by ISO results in international agreements which are published as International Standards.

5.2 ISO 9001:2015 — Quality Management Systems

ISO 9000 is an international reference for quality requirements. It is concerned with "Quality Management" of an organisation. ISO 9001 applies to any organisation in any sector. It provides the framework for a quality management system based on 7 Quality Management Principles: (Table 12).

Table 12: ISO 9001:2015 Quality Management Principles

Principle	Core Idea
1. Customer focus	Understand current and future customer needs; measure customer satisfaction
2. Leadership	Unified direction and purpose; create conditions for engagement at all levels
3. Engagement of people	Competent, empowered people at all levels — quality is everyone's responsibility
4. Process approach	Understand and manage activities as interrelated processes, not isolated tasks

5. Improvement	Continual improvement as a permanent objective
6. Evidence-based decisions	Decisions based on analysis of data, not opinion
7. Relationship management	Manage relationships with suppliers and other interested parties

(ISO 9001:2015. Quality Management Systems — Requirements. International Organization for Standardization, Geneva)

Adoption of these standards is voluntary. The difference between Codex and ISO are given in the table given hereby (FAO, 2011; Marriott et *al*., 2018) (Table 13)

Table 13: Comparison between Codex Alimentarius and ISO standards

Differences between Codex and ISO

Codex	ISO
• Used to develop national regulations • Slow to change • Describe the minimal acceptable practices	• Voluntary • Standards are reviewed every five years. • Describe current standard industrial practices.

5-3-ISO 22000: Food Safety Management System

ISO 22000 is an International Standard which defines the steps an organization must take to demonstrate its ability to control food safety hazards and ensure that food is safe for human consumption. ISO 22000 specifies the characteristics of a management system designed to

- carry out the hazard analysis,
- design the HACCP plan,
- identify the prerequisite programmes (PRP) (the basic hygiene conditions that must be in place before you even start thinking about HACCP.)
- select the operational prerequisite programmes

5-3-1-Relationship between ISO 22000 and HACCP

ISO 22000 has made it easier for organizations worldwide to implement the Codex HACCP system for food safety in a harmonized way, i.e. it does not vary with the country or food product or service concerned. ISO 22000 can be used for certification, and this may be acceptable as an alternative to certification against different national standards.

Implementing HACCP is part of the fundamental requirement of the ISO 22000 standards, and hence HACCP and ISO 22000 are complementary and mutually reinforcing. (Fig. 44).

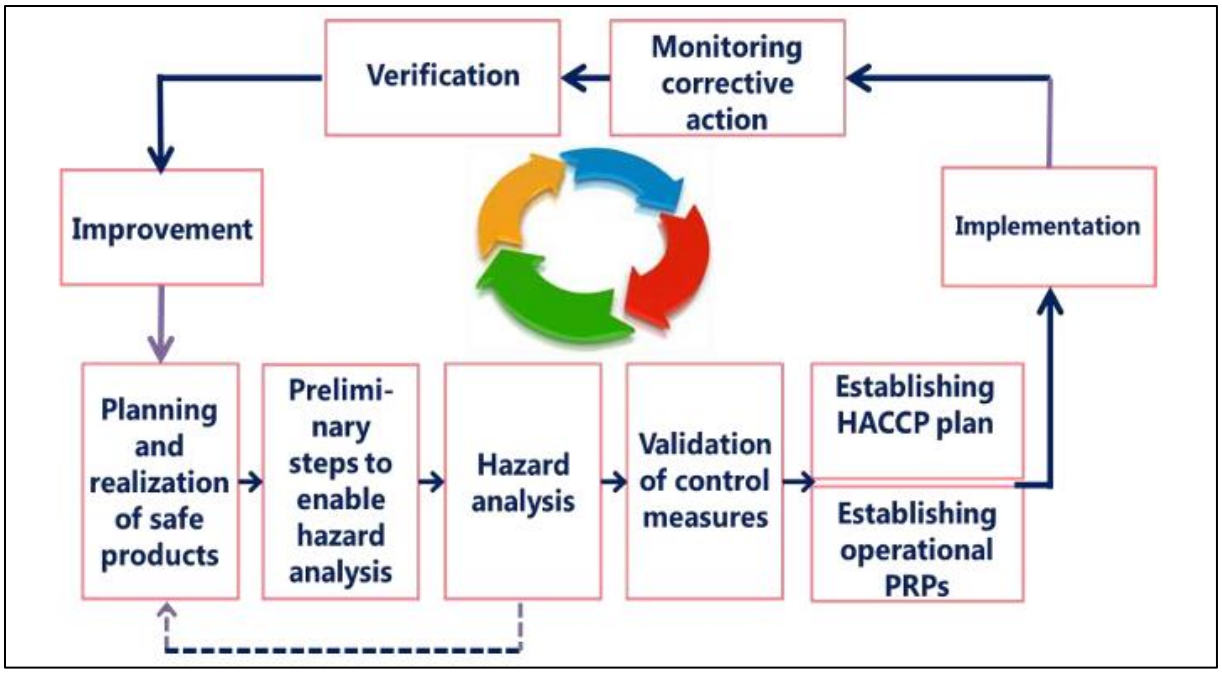

Fig. 44: Steps in implementing ISO 22000

5-3-2-Steps in implementing ISO 22000

The steps for implementing ISO 22000 are described below. Management Commitment Before starting to implement the ISO 22000 food safety management system (FSMS), it is important that the top management be fully committed to the development and implementation of the system. This includes providing financial, infrastructural and competent human resources for the development of the system.

Step 1: Nomination of the food safety team (FST) Your top management should appoint a competent food safety team with a team leader. Preferably the team should consist of a food technologist, microbiologist and supervisors of the the quality assurance, engineering, production and maintenance functions. One of the members of the team should have good knowledge of HACCP/FSMS. If the team members require additional training, this should be arranged by the team leader. The team will play a major role in the development of your food safety management system. If you wish, you could also engage a food safety consultant to support your team, but in no way should this be regarded as an exercise in shifting responsibilities from the team to the consultant.

Step 2: Setting up prerequisite programmes (PRPs)

Depending upon the segment of the food chain in which you operate, you will need to set up the prerequisite programmes for maintaining a hygienic environment in your unit. These programmes include Good Hygienic Practice (GHP), Good Manufacturing Practice (GMP), Good Agricultural Practice (GAP), Good Distribution Practice (GDP) (Annex C of ISO 22000:2005). If you find that your current PRPs are inadequate, you may have to devote additional financial resources and time to improving them. For example, you may need to improve your factory layout, floors, walls, ventilation system, lighting, drainage system and waste collection facilities.

Step 3: Development of the HACCP plan

Before you can develop your HACCP plan, you need to carry out a detailed hazard analysis of each step of the process . This analysis will lead to the identification of critical control points (CCPs), the process step(s) on which exercising control will be essential to preventing or eliminating the hazards or reducing them to acceptable limits. A system for monitoring the CCPs and taking corrective action on the process should be set up for the products or processes. Control measures determined in the HACCP plan and operational PRPs should be validated prior to their implementation.

Step 4: Documentation

FSMS documentation includes the food safety policy and related objectives, documented procedures (for example, procedures for the control of documents, control of records, internal audit, handling of potentially unsafe products, control of nonconforming end product, corrective action and withdrawal of end product), HACCP plan(s), and certain records to demonstrate compliance with HACCP plans and the other requirements of your FSMS. The use of additional documents covering additional procedures and including process flow diagrams, specifications, methods of test, records, wherever required, should also be decided on and the documents developed by the team. A proper system of control of documents and control of records should be introduced.

Step 5: Training, awareness generation and implementation

All employees carrying out activities with an impact on food safety should be competent to do their jobs. Training on monitoring and taking corrective action should be provided to the employees who are responsible for these activities. In addition, your employees should be aware of the relevance and importance of their food safety activities. They should also understand the

need for effective internal communication on food safety issues. After awareness generation and training as needed, system implementation can start and records should be maintained as evidence of the operating FSMS:

Step 6: Internal FSMS audit

The internal audit process determines how well your FSMS is working. Some of your employees should be trained to carry out internal auditing, including inter functional audits. During the early period of FSMS implementation, the audits may be done more frequently; once the system stabilizes, the frequency of audit as prescribed in your internal audit procedure may be followed.

Step 7: Management review

The findings of internal audits, along with information on customer feedback and complaints, analysis of results of verification activities, lessons learned from emergency situations or accidents, if any, product withdrawals, if any, should be reviewed by your top management and decisions taken to improve the FSMS. A system for conducting such reviews on a periodic basis should be introduced.

Step 8: Certification

Certification to ISO 22000 is voluntary. If your top management considers it a necessity, then you may apply for certification to a certification body of your choice. The prerequisite for such certification is effective implementation of the system for at least three months, including one internal audit followed by a management review.

***Action plan**

A period of six to nine months is considered reasonable for fully developing and implementing the FSMS.

5-3-3- Benefits of ISO 22000 FSMS

The implementation of ISO 22000 FSMS will provide both internal and external benefits, for example:

- Improved competence of employees through training and awareness generation, bringing about, among other benefits, clarity about their responsibilities and the designation of authority within FSMS.

- A defined system for obtaining information on emerging food safety hazards and control measures, and on applicable statutory and regulatory requirements.

- Cost savings from reduced instances of producing unsafe products, smaller number of customer complaints, low withdrawal levels of unsafe products from the supply chain.

- ISO 22000 compliance and its certification may generate opportunities for new business, including giving you a chance to become a preferred supplier of the big retail chains.

- Customers will have greater confidence in the food safety of products made by an ISO 22000 compliant or certified company.

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